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DEVELOPMENT TEST A. (U) BIOTECHNOLOGY INC FALLS CHURCH  
VA C S LEWIS ET AL. JUN 80 OPNAV-NOTE-3905-3  
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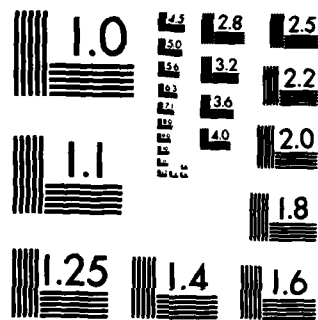
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THE 3rd ANNUAL REPORT

ON

# THE UTILIZATION OF PEOPLE-RELATED NAVY RDT&E

FY 1979

June 1980



*Contract N66001-79-C-0374*

Assembled by

Navy Personnel Research and Development Center  
San Diego, California 92152

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## FOREWORD

This is the third annual report on the Navy's people-related research, development, test, and evaluation (RDT&E) efforts. The primary focus in this issue is on significant research from FY 79. Like its predecessors, this report emphasizes the *application* of the results of people-related RDT&E. It includes selected examples of results already in use, and also reports significant advances in the technology base contributing to this area. The examples presented here are representative; no attempt has been made to document

every instance of utilization that occurred during the year throughout the Navy's people-related RDT&E program.

The report was compiled by the Navy Personnel Research and Development Center, San Diego, California. The manuscript was prepared by BioTechnology, Inc., Falls Church, Va., under contract N660079-C-0374. Appreciation is expressed to each contributing command. Comments and inquiries from sponsoring and user commands are encouraged.

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*NPROE Participation*

## INTRODUCTION

This report describes Navy "people-related" research, development, test, and evaluation (RDT&E) efforts for FY 1979 that have been utilized by operational commands or have contributed to the technology base to support the operational needs of the Navy. People-related RDT&E is a relatively new area of military research which is concerned with issues of manpower, personnel, and training. Its purpose is to enhance operational readiness by improving the attitudes, performance, and management of military personnel.

People-related RDT&E is funded under the Training and Personnel Systems Technology (TPST) program within the Office of the Under Secretary of Defense for Research and Engineering. The TPST program has four major objectives, which also provide the organizational framework for this report. These objectives are:

- *Manpower and Personnel*  
To improve DoD's ability to forecast manpower needs and to recruit and retain manpower in sufficient numbers.
- *Human Factors Engineering*  
To improve the design of weapon and support systems so that personnel can operate equipment with a minimum of training.
- *Education and Training*  
To train military personnel so that they will be effective in performing job assignments throughout their careers.
- *Simulation and Training Devices*  
To improve the services' ability to train military personnel.

This report is one of a number of endeavors the Navy has under way to increase the utilization of newly developed training and personnel systems technology. Within each of the four categories, Navy RDT&E efforts are reported that resulted either in utilization or in significant progress in the technology base to support near-term utilization. Emphasis is placed on the specific operational need, the way in which the research products were utilized, and the payoff or potential payoff.

### **The Need for People-Related RDT&E**

In the 1950s a wave of high-technology weapons began to appear, modifying or replacing WW II-generation systems. Today the application of sophisticated

electronic and computer technologies to military needs continues on an even larger scale. With this accelerating trend has come a new set of concerns for defense policymakers and managers.

These concerns center around the ability of military personnel to effectively operate and maintain systems of increasing complexity. The problem is compounded by the limited ability of an all-volunteer force to attract and hold highly qualified people, and by the dwindling availability of qualified military-eligible people in the nation's manpower pool. As stated in October 1979 by Dr. Walter La Berge, Principal Deputy Under Secretary of Defense for Research and Engineering:

The most significant problem facing all Military Services today is the acquisition, training and retention of young men and women who are capable of operating and maintaining the technical equipment now being put into the field.

This situation has brought about a growing awareness of the balance that exists between personnel and hardware in the total force. People-related RDT&E is in large part an attempt to optimize that balance by providing system developers with data that will ensure that man's role in the man-machine equation is a productive and satisfying one.

### **The Importance of People-Related RDT&E**

The importance of such efforts is gaining recognition at all levels of the DoD and the military services. In the FY 80 DoD annual report, Secretary of Defense Harold Brown addresses this subject under the heading *People*:

The overriding Defense manpower objective is to increase the combat effectiveness of the Armed Forces. In that effort the most important factor, often taken for granted in discussions of sophisticated equipment, is attracting and retaining capable, motivated people—the soldiers, sailors, airmen, and marines who comprise our forces and the civilians who maintain and support our forces.

Elsewhere in the same document, under a discussion of current emphases within the Science and Technology (S&T) Program, Secretary Brown makes clear the

importance of developing training and personnel technology to meet these needs:

As personnel costs continue to be the largest single item in the defense budget, I plan to continue emphasis on this aspect of the S&T Program. It is important that the Department develop procedures, techniques and policies that promote efficient recruitment, training and matching of people with the combat environment. In particular, we plan to continue to emphasize the development of simulators and training devices as a means of not only reducing costs, but also increasing individual and crew operational proficiency.

Deputy USDRE La Berge has also stressed the particularly critical need for training technology:

The personnel and training demands faced by the Services over the next 10-15 years are immense and pose a serious threat to readiness. We need new systems but we also want them to work and to be maintained properly. The requirement to solve problems related to personnel training is becoming more urgent.

The issues of recruitment, attrition and retention, training, morale, and readiness are all closely interlinked. High attrition, for example, means higher recruitment needs, increased training costs, and lower morale. Consequently, the RDT&E efforts reported here often have secondary impacts in a variety of areas other than their immediate focus. Better selection of recruiters, USMC Drill Instructors, and Recruit Company Commanders, for example, can result in Navy or Marine Corps enlisted personnel who are better adapted to service life, better qualified to perform their tasks, and more likely to reenlist for further service.

A systematic means of teaching "A" School-related basic skills to marginally qualified recruits and enlistees will, by augmenting the numbers of those who can be trained in the technical schools, reduce the effort and expenditures necessary to recruit more highly qualified young people, while at the same time improving the retention of these better-utilized and thus better satisfied individuals.

The accession requirements model reported here will not only allow recruitment levels and policies to be tailored to future needs, but by producing a more well-designed force structure it will reduce the turbulence and morale problems associated with over- or undermanning, improving readiness as well.

Advances in computer-based technologies, particularly those that combine speech recognition and synthesis with interactive computer capability, present a major opportunity for people-related developments in training. The same technologies that offer inexpensive, hand-held language aids for travelers, knowledge

and memory games for children, and TV/arcade electronic games can teach basic language and math skills to Navy recruits and air traffic control procedures to ATC students. There is typically a 7-10 year gap between the development and application of a new technology. People-related RDT&E attempts to reduce this time lag wherever such technologies are applicable to the needs of the training and personnel systems.

Training and personnel technology accounts for about 4 percent of the DoD's Science and Technology Program, and about 2 percent of all RDT&E conducted in the Navy. Compared to hardware development, these efforts are relatively inexpensive. Yet, as the examples presented in this report will attest, when properly utilized they have the capability to greatly improve the operation and maintenance of the Navy's highly technical weapons and support systems. Additionally, in their impact on personnel as people, they bring improvements in morale, attitudes, and performance that enhance readiness in ways that weapons systems alone cannot.

#### Utilization and Technology Base Advance

Usable research products are seldom the result of a single, isolated effort. Rather, most are the by-products (generally intentional) of a process which involves building onto the technology base that supports development. Projects which advance the technology base are thus equally important as those which result in utilization, because they reduce the gap that exists between an identified Navy operational need and the technical capability necessary to meet that need.

Although this report focuses principally on instances of utilization and on the actual payoff that has been realized, significant contributions to the technology base are also pointed out, along with the potential payoff such progress represents. Most of the project summaries also include a diagram depicting successive developments in the technology base that led to the effort being described. Because the terms "utilization" and "technology base advance" are central to this report, they are defined in detail below.

#### ● Research Utilization or Application

Any change involving:

- Initiation or modification of regulations, orders, doctrines, policies, or manuals.
- Development of or change in training programs or courses of instruction.
- Development or modification of equipment.

#### ● Technology Base Advances

Any advancement in the state of the art involving:

- Basic research. Scientific study and experimentation directed toward increasing knowledge in those fields related to long-term



national security needs. It provides fundamental knowledge for the solution of identified military problems and furnishes part of the base for subsequent exploratory and advanced developments in defense-related technologies and functional capabilities. (Funds for this type of research come from Program Element 6.1.)

- Exploratory development: All efforts directed toward the solution of broadly defined problems; short, major development programs with a view to developing and evaluating technical feasibility. (This type of development is funded under Program Element 6.2.)
- Advanced development: All projects that have moved into the development of systems for test. The prime result of this type of effort is proof of design concepts rather than development for service use. Projects in

this category have a potential military application. (This level of development is funded under Program Element 6.3.)

The race to field superior weapons systems has given us unmatched technology strength, both in hardware and in the people-related sciences. But the emphasis on hardware has taken priority. Developments there have outstripped the corresponding need for people-related developments. And yet the readiness and reliability of our weapons and support systems can be no greater than the readiness and reliability of the personnel who operate and maintain them. It is clear that the time has come to establish a coordinated linkage between these two parallel lines of development. As Vice Admiral Robert Baldwin, Chief of Naval Personnel, noted last year in announcing his office's redesignation as DCNO (Manpower, Personnel and Training), the Navy is moving in the direction of policies designed to "better ensure that the people factor is considered in every management decision."

## **MANPOWER AND PERSONNEL**

DoD defines this area of People-Related RDT&E as follows:

"Development of techniques/methods for utilizing available personnel resources through improved selection, job assignment, organizational analysis and management techniques to meet combat-available and projected force needs."

The Navy must continually improve its manpower and personnel processes. These processes include: estimating manpower requirements and force levels; developing advanced methods of recruiting, classifying, selecting and assigning officers and enlisted personnel; increasing productivity; and retaining qualified people in the Navy and Marine Corps. A major focus at the present time is on developing standardized selection procedures for key positions, based on measures of actual job performance.

Projects in this category include:

- Reducing Attrition from Navy and Marine Corps Basic Training
- Computerized Adaptive Testing of Ability
- Effects of Inflation on the Navy Procurement Workload
- More NROTC Engineering/Science Majors
- Selection of Marine Corps Drill Instructors
- Selection of Recruiters
- A Model for Forecasting Accession Requirements
- Selecting Recruit Company Commanders

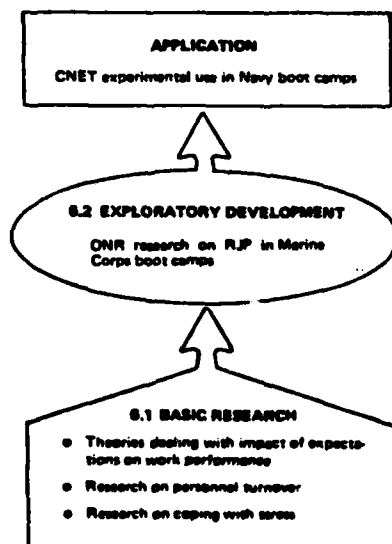
## REDUCING ATTRITION FROM NAVY AND MARINE CORPS BASIC TRAINING

### Need

Since the mid-1970s, attrition rates from Navy and Marine Corps basic training have averaged over 10%. Research shows that a major factor in this early turnover is a mismatch between expectations of life in boot camp and actual experiences there. Although most of the research has been conducted in Marine Corps settings, Navy recruits were known to be having similar problems, and so the principles developed are being applied there as well.

### Performing Activity and Program Element

This project was performed by the Office of Naval Research (ONR). Funding was provided under Program Element 62763N. Program dynamics in support of this effort are depicted in the diagram below.



### Approach and Results

It has been established, in both military and industrial settings, that turnover among new entrants can be reduced through a "realistic job preview" (RJP). Using this approach, the employer lets new employees (recruits) know exactly what to expect in the way of early training. RJP is a "tell-it-like-it-is" tactic that aims to reduce the extent of the mismatch noted above.

In the Marine Corps version, as in its later Navy counterpart, the RJP is a film made during actual training. Marine (or Navy) recruits and their drill instructors, acting as narrators, explain what is happening and why. Negative as well as positive information is presented to show the realities of basic training to emphasize that successful recruits, even though

enter with apprehension, can deal with the adversities of training when they understand the reasons for it. The RJP films are all specific to the basic training center in which they are shown; by showing the viewer scenes that can be easily verified, the films gain credibility. While the films were in preparation, recruits and drill instructors were asked to review preliminary footage for accuracy, and necessary corrections were made. These RJP films were produced by in-house Navy and Marine Corps instructional TV units.

Experimental use of the RJP method was first tried in the Marine Corps recruit training center at Parris Island. Results there showed a reduction in attrition from about 15% to 10%. Although encouraging, this finding was not statistically significant. An unanticipated benefit of RJP was that recruits seeing the film had, on the average, better "Military Skill Marks" than those of the control groups. Experimental and control groups have subsequently been tracked for a year beyond basic training, and they continue to show the differential effects of RJP. More of the experimental group tended to remain in the Marine Corps—attrition rates were 20% and 33%, respectively. These results are statistically significant.

### Utilization/Technology Base Advance

After the experiment at Parris Island, new RJP films were produced for the Marine Corps' San Diego recruit training center, and for female recruits. The RJP is now shown to all new entrants in the Marine Corps (about 40,000 per year).

The Navy's Chief of Technical Training has conducted an experimental assessment of the effects of RJP on naval recruits. The results of that work are not yet available. On the basis of preliminary findings, however, the RJP is now being shown to all recruits at the San Diego recruit training center. By February 1980, all recruits at the Navy's three boot camps will view RJP films.

### Payoff/Potential

Top personnel managers have reacted positively to the apparent success of this RJP approach. Extensions of the technique to new areas have been initiated. For example, the Navy is considering showing RJP's of their future work environment to newly graduated "A" school students, as a way to ease their transition into operational units. Similarly, the Marines are studying the feasibility of using RJP as a way to reduce unauthorized absentee (UA) and desertion rates among individuals being transferred between operating units.

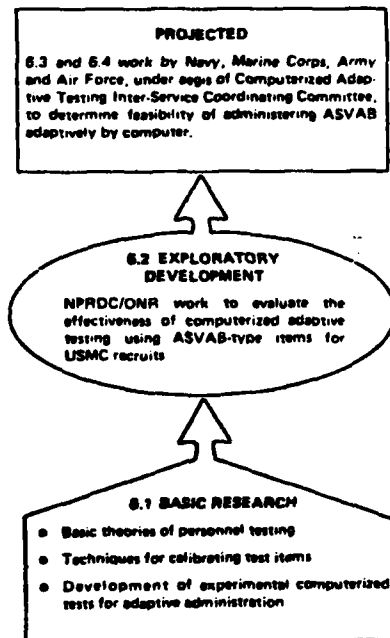
## COMPUTERIZED ADAPTIVE TESTING OF ABILITY

### Need

The Navy and Marine Corps need personnel selection tests that are more precise and reliable, that minimize problems with test security, and that can be administered more quickly and more economically than current tests. There is also a need for testing that can more accurately measure people at lower ability levels than is possible with conventional personnel selection tests.

### Performing Activity and Program Elements

This work was performed by the Office of Naval Research and by the Navy Personnel Research and Development Center (NPRDC), under a university contract. Funding was provided under Program Elements 61153N and 62763N. Program dynamics in support of this effort are depicted in the diagram below.



### Approach and Results

There are a number of ways to adapt a test to a person during the course of testing. This project compared the different methods on the basis of measurement efficiency, accuracy, and validity on an individual level. Although no single approach was found to be uniformly better than the others across all situations, these comparisons have eliminated a number of possibilities. In addition, the results help us better understand existing strategies, and will guide the selection and design of an optimal strategy for each Navy application.

The effects of several specific changes to current testing procedures have been studied. The changes have included (1) providing immediate feedback of results, (2) varying the item sequence (i.e., adaptive, as opposed to conventional linear administration), (3) varying average item difficulty, and (4) pacing item presentation. In each case, the investigators studied the effects of these modifications on test performance, test anxiety, and motivation. The results showed that adaptive tests are more reliable and valid than conventional tests. Immediate feedback during testing reduced the impact of motivation and test anxiety on test scores, thereby increasing test validity.

The final phase of this project was a cooperative effort between ONR and NPRDC to see whether these findings applied to a military recruit population. At the Marine Corps Recruit Depot in San Diego, 530 Marine recruits were administered either verbal ability or arithmetic reasoning Armed Services Vocational Aptitude Battery (ASVAB)-type items. The research compared adaptive and conventional computer-administered tests. Results confirmed that adaptive administration of ASVAB-type questions to military recruits yields scores with higher reliability than the conventional approach.

### Utilization/Technology Base Advance

This project demonstrated that both the time and the cost of testing can be reduced and the accuracy of assessment improved with adaptive testing. Because of this, and at the urging of the Marine Corps, DOD established the Computerized Adaptive Testing Inter-Service Coordinating Committee (CATICC) in early 1979. Members of this committee represent personnel policy and personnel R&D activities of each Service. CATICC coordinates research to determine the feasibility of military recruit testing using this adaptive technology. A field test of a prototype system is expected by the end of FY 82.

A computer-based adaptive testing laboratory at the University of Minnesota is being used to give tests on terminals via long-distance multiplexed telephone lines.

### Payoff/Potential

Increased reliability and efficiency mean lower costs of testing. Also, a computer-based system will be more efficient in recordkeeping and assignment procedures. But since present testing techniques work poorly on low-ability personnel, the most valuable result will be greatly increased test-score validity for that part of the applicant population. This will improve military assignments, reduce training losses, and perhaps expand the size of the military manpower pool.

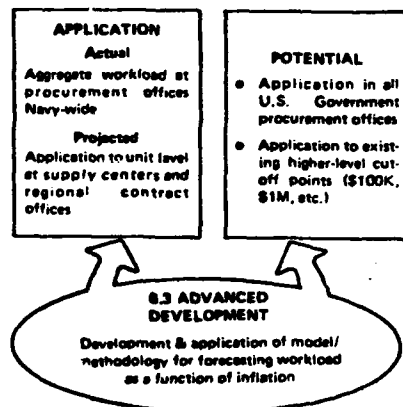
## EFFECTS OF INFLATION ON THE NAVY PROCUREMENT WORKLOAD

### Need

The workload at Navy procurement offices has been increasing rapidly during the past several years. The lack of quantitative tools to forecast this growth has made personnel planning difficult to perform and to justify. There has also been a need to understand why such an increase is occurring—particularly to justify policy changes that would result in a more constant level of workload and in reduced personnel turbulence.

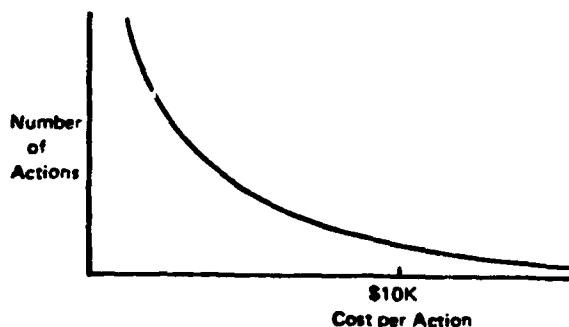
### Performing Activity and Program Element

This project was performed by the Navy Personnel Research and Development Center. Funding was provided under Program Element 63707N. Program dynamics in support of this effort are depicted in the diagram below.



### Approach and Results

A rough distribution of procurement actions in relation to their cost is shown in the figure below.



Distribution of Procurement Actions vs. Cost

The important point on this curve is the one associated with \$10,000. This is the maximum cost at which an action is defined as a small purchase. The significance of this value is that actions of greater value (which must be handled as contracts) require in excess of 30 times more effort to process than do small purchases.

The methodology developed in this project is able to relate the movement of this curve to the inflation rate. A mathematical model, generated from historical data, produces a forecast of the total number of procurement actions, along with the number (or percentage) of these actions that will become contracts solely on the basis of the inflation rate.

More importantly, the model provides a method to quantify the change that must be made in the maximum balance of the small purchase in order to keep workload constant. For example, if it were desirable to have 1.5% of all procurements be contracts (which was the case in 1976), the maximum value of the small purchase should have been raised to \$20,700 in 1978.

### Utilization/Technology Base Advance

The results of this analysis were presented in a briefing to the Commander, Naval Supply Systems Command (NAVSUP), who then initiated an effort to seek congressional action on raising the maximum value of the small purchase. While waiting for this action to be approved, the procurement division of NAVSUP is using the model to forecast the increasing workload, so as to justify increases in manning levels necessitated by the current high inflation rate.

At the request of NAVSUP, the methodology is now being computerized and results broken out to the unit level. This will allow management to compare the work level and manpower requirements of each of its units.

The technical development of the methodology has been reported in NPRDC TN 80-4 and was also presented at the 44th Symposium of the Military Operations Research Society.

### Payoff/Potential

Between FY79 and FY80, the workload increase at procurement offices within the supply system required an increased ceiling of 19 people at the regional contracting offices alone. This increase was due almost entirely to the inflation rate and to the arbitrary ceiling on the small purchase. If this analysis results in an appropriate change to the small purchase ceiling, this increase in manpower requirements can be eliminated.

At a cost of \$60,000 per employee (including overhead), that additional manpower will cost the government \$1,140,000 this year. Similar increases are

being required at all other procurement offices throughout the supply system, in the other system commands, in other services, and probably in other agencies. The

total savings to the government that would result from a change in the small purchase ceiling would clearly be extensive.

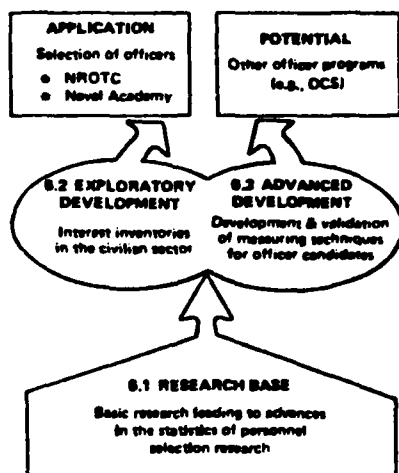
## MORE NROTC ENGINEERING/SCIENCE MAJORS

### Need

A current emphasis in the NROTC Scholarship Program is on identifying those candidates who are interested in and have the ability to perform well in the engineering and science (E-S) areas. In recent years, approximately half of the officers commissioned from this program have elected either an engineering or a science major. However, to fulfill the Navy's present and future demands for technically trained officers, the proportion of midshipmen choosing an E-S major will have to be increased considerably. One way to meet this goal is to identify and select from the applicant pool those individuals who are most likely to pursue a technical major.

### Performing Activity and Program Element

The research for this project was conducted by NPRDC in response to Navy Decision Coordinating Paper NDCP-Z0107-PN, under the mission sponsorship of the Deputy Chief of Naval Operations (OP-01). Funding was provided by Program Element 63707N. Program dynamics in support of this effort are depicted in the diagram below.

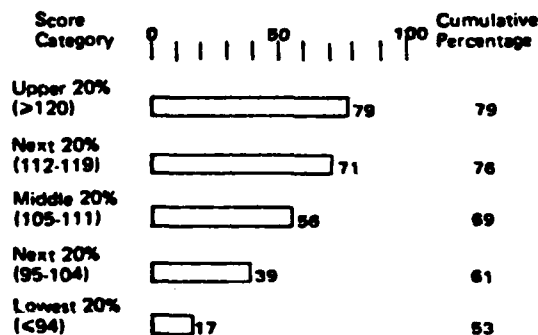


### Approach and Results

The preferred approach is one that would allow the voluntary system of electing a major to be retained, while increasing the number of students choosing E-S majors. It was determined that the best way to do so would be to modify the selection procedures so that those selected for future classes were more likely to choose those majors.

To meet this need, NPRDC investigated the use of the Strong Vocational Interest Blank for identifying those NROTC Scholarship applicants who were most likely to choose an engineering or science major. Statistical comparisons indicated clear-cut differences between the vocational interests of those who chose E-S majors and those who did not. A scale developed specifically to measure these differential interests showed considerable accuracy in predicting choice of major when it was evaluated on an entire NROTC class.

As shown in the accompanying graph, those midshipmen scoring in the top fifth of the scale selected engineering and science majors more than four and one-half times as often as those who scored in the lowest fifth.



Percentage of NROTC Midshipmen Expected to Select an Engineering or Science Major in Each Score Category

### Utilization/Technology Base Advance

As a consequence of the favorable research results, the NROTC Engineering-Science (E-S) Scale was

implemented to select future classes beginning with the class entering September 1978.

The NROTC Scholarship Program Selection Board met in February 1978 to review the applicants' files and choose the scholarship students for this class. The principal investigator of this project was invited to address the Board and provide its members with an explanation of how the NROTC E-S Scale was developed, its meaning, and how to interpret the scores.

With the cooperation of the Navy Recruiting Command and the Chief of Naval Education and Training, NPRDC has set up procedures to maintain a complete data base on all NROTC Scholarship students.

The data base will consist of all selection scores, including scores on the NROTC E-S Scale, as well as grades, attrition data, and choice of major. This will allow for future monitoring of the Scale's validity.

#### Payoff/Potential

It is expected that the results of this project will lead to a significant increase in the number of technically trained officers in the command structure of a technologically advanced Navy. While this increase is measurable, the potential enhanced readiness resulting from having greater numbers of technically trained officers cannot be measured in the usual quantitative terms.

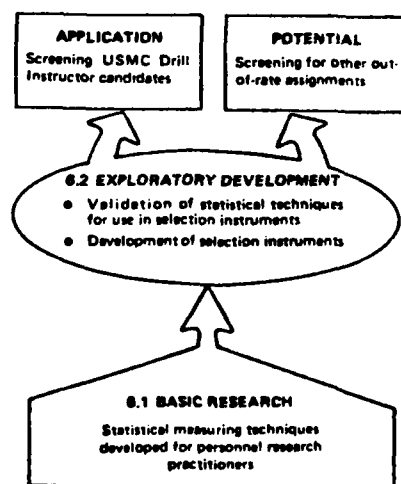
## SELECTION OF MARINE CORPS DRILL INSTRUCTORS

#### Need

The Marine Corps drill instructor plays a crucial role in the training of Marine recruits. Many Marines selected for this demanding duty have been unable to satisfy the training and/or job requirements. More objective selection standards are needed.

#### Performing Activity and Program Element

The research for this project was performed by the Navy Personnel Research and Development Center under the sponsorship of the Commandant, U.S. Marine Corps. Funding was provided by Program Element 62763N. Program dynamics in support of this effort are depicted in the diagram below.



#### Approach and Results

Three objectively scored selection instruments—the Strong-Campbell Interest Inventory, the Leadership Opinion Questionnaire, and a Biographical Questionnaire—were administered to students entering Drill Instructor Schools. Selection instrument scores, along with service record data, were related to performance in school and to performance on the job.

Both the Biographical Questionnaire score and a composite score comprised of volunteer status, General Classification Test score, and level of education were found to be predictive of performance in Drill Instructor School. Performance in Drill Instructor School, in turn, was found to be predictive of performance on the job.

#### Utilization/Technology Base Advance

The sponsors at Headquarters, Marine Corps have been briefed on selection instrument development, cross-validation results, and research recommendations. The recommended selection procedures are now being implemented as a part of the Marine Corps personnel selection system. Navy Personnel Research and Development Center will continue to provide professional assistance in the establishment of norming tables and in evaluating the predictive validity of the new selection procedures.

#### Payoff/Potential

The research data indicate that the use of these new selection procedures could yield up to a 50 percent reduction in Drill Instructor School attrition rates, and may also result in better performance by Marines in the field.





## OF RECRUITERS

### Approach and Results

A trial battery of personality, interest, and biographical inventory questions was administered to a geographically representative sample of Navy and Marine Corps recruiters. The items in this trial battery were subjected to factor analysis and additional items were developed to tap salient recruiter performance dimensions. This process resulted in a revised selection battery, which was then administered to a new sample of Navy recruiters.

It was found that the selection battery could effectively predict the strength of a recruiter's selling skills, human relations skills, organizing skills, and overall performance, as well as the recruiter's actual enlistment production.

### Utilization/Technology Base Advance

The sponsors at Navy Recruiting Command and at Headquarters, Marine Corps have been briefed on the development and validation of the selection battery. These selection procedures are now being implemented as a part of the recruiter selection system. Navy Personnel Research and Development Center will continue to provide professional assistance in evaluating the new procedures in an operational environment.

### Payoff/Potential

The research data indicate that use of these new selection procedures could yield an approximate 10 percent increase in recruiter productivity.

## NG ACCESSION REQUIREMENTS

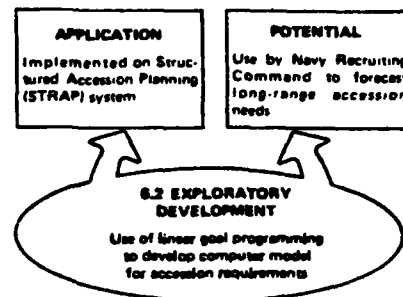
recruits, levels of attrition and retention, and promotion policies.

Techniques for forecasting these supply factors are therefore essential in reviewing alternative manpower plans and identifying those categories wherein manpower shortages or overages are likely to develop.

### Performing Activity and Program Element

The model was developed by the Navy Personnel Research and Development Center, under Program

Element 62763N. Program dynamics in support of this effort are depicted in the diagram below.



### Approach and Results

The objective was to develop a computer model that allows the user to identify accession plans which the Navy would come as close as possible attaining manpower strength goals, and that offers ability to emphasize some goals more than others. The technique employed for this purpose is linear goal programming, which allows a set of possibly conflict manpower goals to be manipulated until a feasible configuration is obtained. Model outputs include optimal number of recruits for each year of planning horizon; the force structure, arrayed by time in-service and paygrade, for each year; and information

## SELECTING RECRU

### Need

Recruit Company Commanders play a critical role in the initial training of Navy enlisted personnel. As yet assignments to company commander duty have been based upon selection criteria that are neither standardized nor formally validated against measures of on-the-job performance. Improved selection procedures are needed so that only highly qualified personnel are assigned to this important training function.

### Performing Activity and Program Element

The research for this project was performed by Navy Personnel Research and Development Center under the sponsorship of the Chief of Naval Technical Training. Funding was provided by Program Element 62763N. Program dynamics in support of this effort are depicted in the diagram on the right.

#### **Approach and Results**

Company commanders assigned to the Navy's three Recruit Training Commands were administered an experimental battery of tests consisting of a Leadership Questionnaire, the Work Environment Preference Schedule, a Biographical Questionnaire, and the Strong Vocational Interest Blank. Test items were then checked for their ability to predict performance measures derived both from a factor analysis of supervisory ratings and rankings and from inspection scores assigned to company performance by the Military Evaluation Department.

Out of this evaluation only the Strong Vocational Interest Blank score, validated against company inspection scores, emerged as an effective predictor of company commander performance. However, one other test, the Biographical Questionnaire, did show enough promise to warrant its consideration for further research and re-evaluation.

#### **Utilization/Technology Base Advance**

The offices of the Chief of Naval Technical Training, the Chief of Naval Operations, and the Naval Military Personnel Command have been briefed on selection instrument development, validation results, and research recommendations. The recommended selection procedures are now being implemented in the Navy personnel selection system. Navy Personnel Research and Development Center will continue to assist in evaluating the results of applying the selection procedures in an operational environment.

#### **Payoff/Potential**

The research data indicate that 69 percent of those scoring in the top 20 percent on the new selection test will be above-average company commanders, versus 31 percent of those scoring in the bottom 20 percent. As these data are based upon company performance, it is clear that better selection of company commanders will also produce a higher level of performance by recruits.

## **HUMAN FACTORS ENGINEERING**

DoD defines this area of People-Related RDT&E as follows:

*"Development of improved methods and technologies for the analysis, design, and evaluation of equipment/systems for safer and more efficient operation and maintenance."*

The Navy needs equipment designed in such a way that people can do their jobs faster, more accurately, and more safely when they operate, maintain, or control that equipment. The Navy's Research and Development program in Human Factors Engineering is involved in all systems, from their initial formulation to test and evaluation. The program develops procedures and technology that will be applied by practicing human factors engineering specialists in various development agencies and contractor firms.

Projects in this category include:

- Improving D&T Operator Performance
- Navy Technical Information Presentation System (NTIPS)
- Comparing Male and Female Performance in Non-Traditional Jobs
- Decision Support for Command and Control
- Operator Control of Underwater Teleoperators and Vehicles
- Operator Performance with Imaging Systems
- Evaluation of Potential NTDS Symbols
- Energy Management Display for the Air Combat Maneuvering Range

## IMPROVING D&T OPERATOR PERFORMANCE

### Need

Problems in fleet antiair warfare (AAW) performance are a continuing concern to Commander, Seventh Fleet. The results from fleet AAW exercises have consistently shown that too many air targets are not detected and engaged by fleet task forces. Initially, an intensive effort was made to improve AAW performance by improving system hardware. After 18 months of such effort produced little improvement, another possible source of AAW problems was identified: lack of detection and tracking (D&T) operator effectiveness. Commander, Seventh Fleet then asked for both assistance in defining D&T operator performance problems and recommendations for solving them. This request was made through the Seventh Fleet Science Advisor to the Navy Science Assistance Program (NSAP). NSAP then appointed an NSAP human factors representative from the Navy Personnel Research and Development Center (NPRDC) to ride with Seventh Fleet and study D&T operator activities.

### Performing Activity and Program Elements

This project was performed by the Navy Personnel Research and Development Center with funding provided under Program Elements 62712N and 62543N.

### Approach and Results

The study was performed concurrently by the NSAP human factors representative in Seventh Fleet and NPRDC personnel working in San Diego. Data from the fleet were collected by various means: questionnaires filled out by D&T operators and their supervisors; individual interviews with many combat intercept control (CIC) personnel involved with detection and tracking; extensive observations of D&T operator performance aboard ship; and performance of the D&T task aboard ship by the researcher. The at-sea data were collected from two carriers (USS MIDWAY and USS CONSTELLATION) and two cruisers (USS LEAHY and USS WORDEN).

The following types of data were collected aboard ship: (1) attitudes of D&T personnel toward the D&T job; (2) opinions of officer and enlisted personnel about how well the detection task is currently being performed; (3) D&T operator working conditions; (4) workload; (5) shore-based and shipboard training of D&T operators; (6) morale and motivation of operators and their supervisors; (7) feedback information relative to D&T operator performance; (8) factors that may cause targets to go undetected; and (9) relevant personnel data, including D&T experience.

The objectives of the data collection performed in San Diego were to first identify and then evaluate shore training available to D&T operators.

The study identified a number of problems that are hindering effective D&T operator performance, and thus degrading fleet AAW. The major problems are that: (1) D&T operators must spend excessive time at the radar scope (sometimes up to eight hours); (2) the total workday is too long; (3) sleeping accommodations are poor; (4) personnel shortages result in too few personnel being assigned as D&T operators; (5) radar brightness is not being properly adjusted for optimum sensitivity; (6) both detection and tracking are performed by the same person, even in high trackload conditions; (7) D&T operators are not given enough information about the tactical situation with which they are dealing; (8) personnel with insufficient radar scope experience are being used as D&T operators; (9) training in detection skills and procedures is inadequate, both ashore and aboard ship.

The major recommendations that emerged from this study are: (1) rotate D&T operators to nonscope tasks every 30 to 60 minutes; (2) reduce total workload so that D&T operators have at least eight hours a day for sleep and personal business; (3) improve sleeping accommodations so that D&T operators can sleep without interruption; (4) provide training in radar scope brightness adjustment; (5) assign detection tasks and tracking tasks to different operators during periods of high trackload; (6) use operators with greater skill on the radar scope to perform detection; (7) provide D&T operators with more information about the existing tactical situation; (8) provide better feedback about the adequacy of D&T operator performance and AAW performance in general; and (9) study ways to provide better training in skills necessary for detection. In the report, each recommendation was discussed in detail, along with the underlying rationale.

### Utilization/Technology Base Advance

The results of this research were presented in oral briefings to COMSEVENTHFLT, COMCRUDESGRP Seventh Fleet, COMTHIRDFLT, Third Fleet General Board, Commander Training Force, Pacific, COMNAVAIRLANT, NAVSEA 06, and about a dozen other groups, including the Atlantic Fleet Navy Tactical Data System (NTDS) Conference and the Surface Missile Systems Conference. Two reports were published: one describes the problems found, and the other contains, in addition, the recommendations for problem solution.

As a result of the briefing to COMSEVENTHFLT, a message was sent to all Seventh Fleet units describing many of the problems found in the study, and recommending that all units take action to try to solve them. A copy of the first report was also distributed to these units. Three documented reports of utilization have

been received thus far: Commander Task Force 75 and Commander Task Group 77.4 have both described substantial planned changes in D&T procedures and working conditions. In addition, Commander Destroyer Squadron 5 conducted an AAW seminar on the subject.

#### Payoff/Potential

This human factors research documented the effects of operator inadequacies on reduction of capability in a complex AAW system. Even though the system hardware was generally working within specifications, operator deficiencies rendered the AAW system less than fully effective. Clearly, operators are an integral part of our systems and provision must be made to ensure that they are able to perform their tasks effectively. A significant payoff from efforts such as this one is that increases in system effectiveness

can be obtained without the large expense of modifying complex and sophisticated equipment. In this case, actions taken to upgrade operator working conditions, morale, and job procedures can be expected to provide significant increases in overall AAW systems effectiveness. The effectiveness of any newly acquired system is likely to fall below expectations unless action is taken to ensure that trained, skilled, and motivated operators are present to man and maintain it.

NPRDC will participate in use and evaluation of an operator-aiding device developed under NSAP funding and based on Seventh Fleet findings. This device will assist the D&T operator to correctly adjust his radar scope brightness, and will provide synthetic target input for operator feedback and evaluation. Other specific recommendations for dealing with the problems identified will be developed and tested in the fleet.

## NAVY TECHNICAL INFORMATION PRESENTATION SYSTEM (NTIPS)

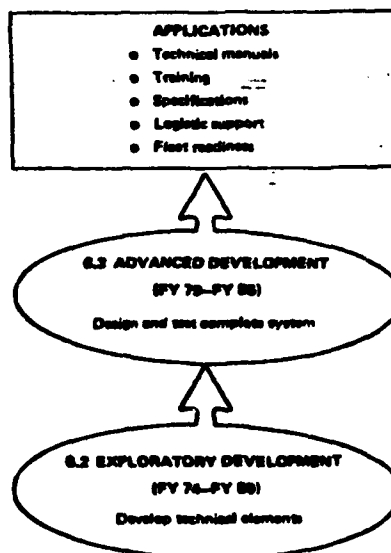
#### Need

Serious deficiencies exist in Technical Information (TI) accompanying hardware systems in the fleet. Consequently, material readiness is reduced through inefficient manpower utilization and poor maintenance, training, logistic support, and operations.

In September 1979, a letter from the Chief of Naval Material (CNM) to the Chief of Naval Operations (CNO) summarized fleet problems associated with technical manuals, and reported what is being done to correct these problems and what remains to be done. The CNM identified NTIPS as the Navy's long-term solution to TI problems.

#### Performing Activity and Program Elements

The David W. Taylor Naval Ship Research and Development Center is technically responsible for the development of NTIPS. Supporting research is being provided by the Training Analysis and Evaluation Group and the Navy Personnel Research and Development Center. A support contractor is responsible for designing the system. Planning, programming, and budgeting for the implementation and continuing utilization of this system, once it is designed, are being carried out by the Deputy Chief of Naval Operations (Logistics), the Deputy Chief of Naval Material (Logistics), and the NTIP Program Office. Funding comes from Program Elements 62763N and 63727N. Program dynamics in support of this effort are depicted in the diagram on the right.



#### Approach and Results

A systems approach is being taken to develop a single process for the complete control of hardware-related TI. The needs of all user communities are being considered concurrently. Human factors engineering technology and other supporting technologies such as logistics, micrographics, automatic data processing, and publishing are being applied and developed. The

development program is being carried out in three phases:

- I. System and Feasibility Tradeoff Analysis
- II. Critical Element Testing and Detailed NTIP System Design
- III. Prototype Test and Implementation Recommendations.

Phase I has been completed. For a discussion of accomplishments under this phase of the program, see the First and Second Annual Reports on the Utilization of People-Related Navy RDT&E.

Phase II was initiated during FY79. Under this phase, TI problems have been classified and analyzed in 15 categories. Specific design objectives have been established. NTIPS boundaries and interfaces have been analyzed in 19 categories. Working design drawings have been completed for all NTIPS subsystems, namely, TI Definition and Acquisition, TI Generation, TI Mastering and Replication, TI Distribution (to the user site), TI Delivery (to the user), and TI Control. Critical elements of NTIPS have been identified, and the detailed design of these elements has been initiated. The detailed NTIPS design is scheduled for completion at the end of FY81.

To date this research has resulted in the:

- Definition of the interface between the Integrated Logistic Support process and NTIPS, which will reduce costs and errors by working from a common data base.
- Definition of the NTIPS interface with the Training Community, which will insure that the TI is suitable for training and that the needs of the Training Community are met.
- Identification and test of improved formats for presenting TI to pilots and crewmembers, which resulted in an increase in comprehension and recall of safe ejection procedures of as much as 47%.
- Conclusion that a fully automated, digitally based NTIP System capable of providing and controlling variable-medium output (i.e., paper, microforms, electronic displays) is feasible.
- Identification of the implications of an all-digital system which will (1) permit matching the TI to varying experience levels; (2) be amenable to proceduralized job aids; (3) make TI update and configuration management easy; and (4) be capable of covert data collection on maintenance efficiency.
- Development of the concept of modular specifications, in which a computer will be used to select and compile individual requirements statements for each kind of TI as specified by the NTIPS user-data match methodology.

- Development and pilot testing of a new TI quality-assurance approach that resulted in a 75% decrease in the number of errors identified at the time of verification.

- Development of a computer-authoring concept in which the computer is preprogrammed to write course material. A computer-authored training package for Morse Code resulted in an increase of 26% in comprehension by lower-aptitude Signalmen.

- Development of improved presentation techniques for a Flame Spray Corrosion Control TM. Preliminary evaluation of this draft TM during a recent flame spray course resulted in a 20% decrease in classroom training requirements and increased on-the-job proficiency.

#### Utilization/Technology Base Advance

Five short-term TI improvements resulting from this research have been provided to the Systems Commands and Training Community, who are proceeding to implement them. First, as a result of the improved TI format research, an instruction is being developed for use by NAVAIR in the writing of emergency procedures found in pilots' manuals. Second, NAVSEA is currently planning to implement the modular specifications concept. Third, a quality assurance specification based on the new approach described is being used by NAVAIR and being considered for use by the other SYSCOMs. Fourth, the Training Community has adopted the computer authoring programs to write course material on Morse Code for signalmen and meteorological symbols for aerographers mates, and is currently developing programs for authoring maintenance procedures. Finally, the Flame Spray Corrosion Control TM will be provided to NAVMAT and NAVSEA for review and fleet introduction.

#### Payoff/Potential

These and future NTIPS products will assist the fleet in several ways. From the perspective of operators and maintenance technicians, they will show improvements in:

- Quality, accuracy, and consistency of information
- Homogeneity of technical content from school to job
- Efficiency of preparation and control.

Time saved aboard ship through the use of more accurate and more efficient TI can contribute significantly to enhanced readiness.

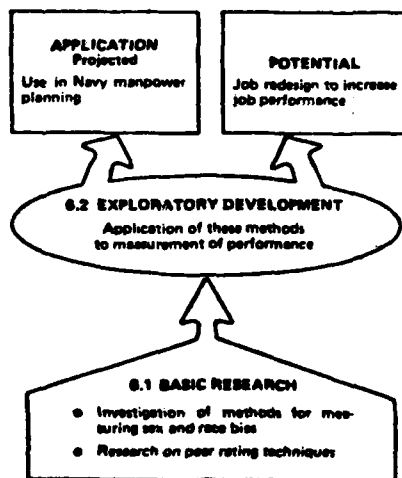
## COMPARING MALE AND FEMALE PERFORMANCE IN NON-TRADITIONAL JOBS

### Need

Since 1976 the Navy has expanded its female recruiting effort, and expects to double the number of women in the Navy between then and the end of 1983. Also, Section 6015 of the U.S. Code was recently amended to allow women to work at certain jobs aboard non-combatant ships. Consequently, an increasing number of enlisted women are entering jobs that have always been male preserves, such as Aircraft Mechanic and Machinist's Mate. Since some of these jobs have not ordinarily been performed by women, it is necessary to determine whether their performance is equivalent to that of men.

### Performing Activity and Program Element

This project was initiated and performed by the Navy Personnel Research and Development Center (NPRDC) in response to a request by the Bureau of Naval Personnel. Funding was provided under Program Element 62757N. Program dynamics in support of this effort are depicted in the diagram below.



### Approach and Results

Peer ratings were used to measure male/female performance. Since peer ratings have been shown to be valid predictors of performance, it was assumed that if the pattern of ratings given to men by the total team was similar to that given to women, then women were performing comparably to men. Each member of a Navy team performing a non-traditional job rated everyone on the team, including himself, in terms of relevant job dimensions. Each team included at least one female, and the members of the team had worked with each other for at least three months.

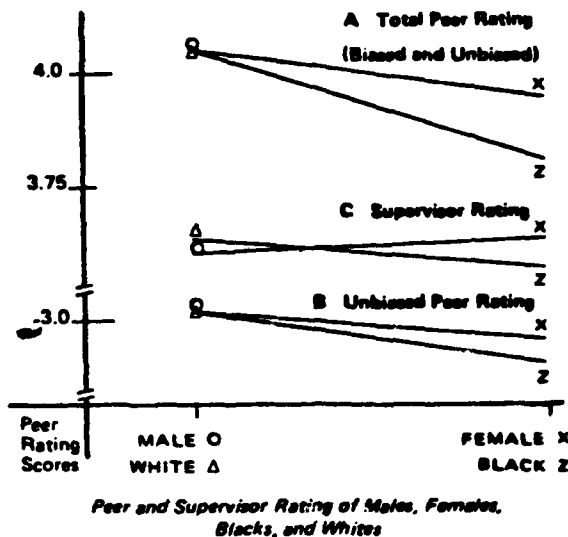
The non-traditional jobs selected for measurement were: Aircraft Controller (AC), Aviation Machinist's Mate (AD), Aerographer (AG), Aviation Structural Mechanic (AM), Aviation Electronics Technician (AT), Electronics Technician (ET), Ocean Systems Technician (OT), and Radioman (RM). Only those jobs which employed a reasonable number of women were studied. An NPRDC researcher traveled to ten Navy shore installations to gather information on 787 enlisted men and 180 enlisted women (18.6% of the total) in pay grades E-3 through E-5. This total included 93 blacks, or approximately 10% of the total.

In most teams a larger number of men worked with and rated a small number of women, often only one or two. Since it was possible that some of these men held discriminatory attitudes toward women and—if they were white—toward blacks, it was necessary to identify biased personnel and eliminate their ratings from the pool of peer ratings. A special sex/race bias test was developed for this purpose—a film showing representative males and females, blacks and whites, tracking a CRT display. Team members were told that this film was a tryout of a new method of evaluating enlisted personnel performance, and that it would enable them to practice ratings by making judgments of the filmed subjects in terms of their tracking performance. Since in reality all of the filmed subjects performed the same, any marked deviation from an equal rating was evidence of bias, and peer ratings from those showing a bias on the film test were eliminated.

The procedure for gathering data was to first administer the film bias test, to follow that by gathering peer ratings, and finally to administer a questionnaire that elicited the subject's feelings regarding (a) job satisfaction, (b) attitudes of supervisors, fellow workers, and women toward him or her, and (c) biographical information.

Although a complete analysis of the data has not been performed, initial analyses indicate that when both biased and unbiased peer ratings are combined to evaluate women's performance, there is a significant difference in favor of men between male and female performance ratings (part A of the figure below). When the biases are eliminated, the difference in ratings between men and women becomes insignificant (part B), although in both cases women were still rated below males. Supervisor ratings, which were gathered at the same time, are significantly lower than total peer ratings but significantly higher than unbiased peer ratings (part C). There is a tendency on the part of supervisors to rate women slightly higher than men, which shows that supervisors tend to adjust male/female performance differences in favor of

women. These data suggest that any performance differences between women and men and between blacks and whites in non-traditional jobs are insignificant. This conclusion is valid even when different ratings and paygrades are taken into account.



#### Utilization/Technology Base Advance

Data from this research increases the Navy's knowledge of how well women can perform in non-traditional jobs, and supports the concept of expanding the use of women in these jobs. When all results are available, the data can help determine additional career fields for women; what jobs women may not be suited for; and how equipment, jobs, and training might be changed to increase the number of jobs women could perform satisfactorily.

The results of this research will soon be available to potential users (primarily military manpower planners) in a final report. Follow-on research is underway to determine whether these non-traditional jobs can and should be redesigned to increase the effectiveness of women performing them.

#### Payoff/Potential

The payoff from this research cannot be measured in monetary terms alone. These data provide support for expanding the use of women in the Navy, which has an important intrinsic value because of the growing difficulty in recruiting qualified males.

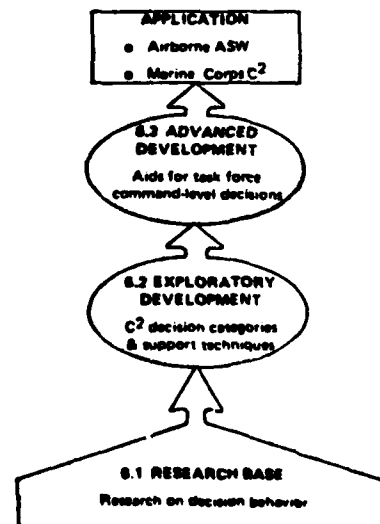
## DECISION SUPPORT FOR COMMAND AND CONTROL

### Need

There is a growing interest in research to enhance the capability of managers, policymakers, military planners, and operational commanders to assess rapidly developing situations and decide upon courses of action. Basic research has investigated human decision behavior and led to the development of models, computer-based procedures, and graphic displays that aid human decisionmaking. The objective of this project is to encourage the transitioning of available decision support techniques into a variety of operational command and control (C<sup>2</sup>) systems. It is sponsored by the Surveillance and Command-Control-Communications (C<sup>3</sup>) Branch, Technology Division, Naval Material Command.

### Performing Activity and Program Element

The Office of Naval Research is responsible for the performance of the work, which is being conducted by several contractors. Funding has been provided under Program Element 62721N. Program dynamics in support of this effort are depicted in the diagram on the right.



### Approach and Results

The types of decisions made in command and control centers were analyzed and characterized.



These C<sup>2</sup> centers included surface ship, marine amphibious brigade, airborne antisubmarine warfare (ASW), and submarine combat centers. Decision-aiding techniques proven successful in other contexts were matched to the types of decisions made in the C<sup>2</sup> centers. These techniques are basically tools to assist decisionmakers in: identifying key factors, structuring the problem, estimating or inferring events, evaluating alternatives, predicting outcomes, and managing and presenting information.

Over the past eight years, many of these tools have been contributed through basic research on decision behavior sponsored by the Office of Naval Research and the Defense Advanced Research Projects Agency. Models of decision behavior have been developed, human biases and distortions in judgment have been measured, and procedural aids for overcoming these distortions have been developed and used successfully in demonstration projects.

A preliminary classification of decisions and aiding techniques was developed under the basic research program, but was not related to specific command and control systems. The current effort is an attempt to become at once more specific (i.e., more relevant to Navy and Marine Corps operations) and more general (i.e., with potential application across many systems), in order to facilitate a wider use of these tools.

There have been two results. First, a standard classification structure and methodology for matching support techniques to classes of decisions has been developed. This will result in a set of general principles that can be applied to any command and control system, eliminating the need for intensive analyses for

each system. Second, decision support techniques are already being transitioned into two of the four command and control systems being studied, airborne ASW and marine amphibious brigade.

#### Utilization/Technology Base Advance

At the Naval Air Development Center, decision aids are being incorporated into the Acoustic Performance Prediction system for airborne ASW. These aids will use environmental data to help decide optimum tactics for target localization, surveillance track, lost contact reacquisition, and attack.

At the Marine Corps Tactical Systems Support Activity, Camp Pendleton, decision aids are being incorporated into the Tactical Combat Operations system, one of several command and control components scheduled for development.

In each case, the research contractor has worked closely with the development agency to analyze the decisions, select the appropriate aids, and develop the concept for implementation. The concepts will be evaluated in simulation facilities at the development site.

#### Payoff/Potential

Decision aids have been shown to help organize information, reduce variability, increase speed, help the decisionmaker achieve objectives, and help achieve operational objectives over the long run. The actual quantitative measure of improvement depends on the situation in the evaluation phase. Such measures will be obtained under a variety of simulated situations.

## OPERATOR CONTROL OF UNDERWATER TELEOPERATORS AND VEHICLES

### Need

Navy undersea support missions span a wide variety of challenging underwater tasks. These tasks include such things as: installing and maintaining undersea sensors and structures; search, localization, and inspection of objects on the seafloor; salvage and recovery of objects in the sea; and rescue of personnel from submersibles and habitations imperiled in the sea. Currently these functions are performed with manned diving systems, deep-diving submersibles, and/or remotely controlled vehicles equipped with sensors and manipulators. The research programs described here focus on the latter two classes of undersea work systems.

From an operator's standpoint, the effectiveness of current systems is limited chiefly by: (a) the

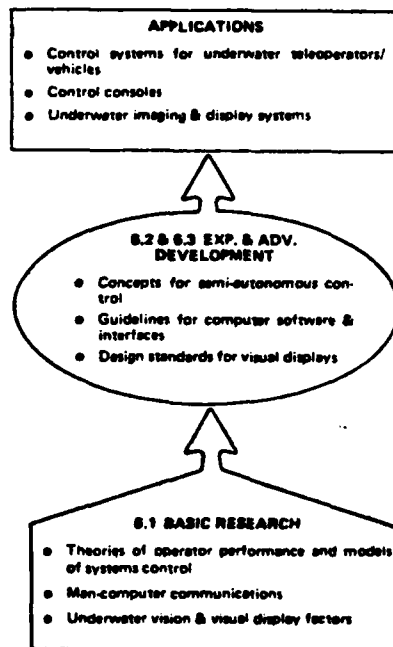
demanding requirement to manually navigate and/or position the vehicle while operating remote manipulators at the work site; (b) the slow and imprecise performance of manually operated manipulator systems; (c) the poor quality of sensory feedback to the operator (particularly, poor visibility in dark, turbid waters).

Recent advances in computer and other component technologies offer the potential for assisting the operator and improving his overall performance. For example, improvements in sensors and computer-aided control techniques for remote manipulators enable the operator to receive readings of force being exerted, and make the resolution of motion possible for manipulator end-points (so that individual joint movements need not be controlled separately).

However, general principles are needed to guide the design of future systems so that the operator's performance capabilities can be matched with the characteristics of these technological advances.

#### Performing Activity and Program Element

The Office of Naval Research is responsible for the performance of these research programs, which have been conducted under contract by investigators at university, industrial, and in-service laboratories. Funding is provided under Program Element 61153N. Program dynamics in support of this effort are depicted in the diagram below.



#### Approach and Results

The following research programs were initiated to develop general principles for use in design:

- theories and models of operator performance with computer-aided semi-autonomous control systems
- operator-computer communication and interfaces
- visual display variables affecting operator performance in this environment.

The technical approaches employed in these programs included analytical studies, model develop-

ment, and laboratory experiments. The analytical studies produced formal ways of identifying operator control functions and tasks required for various degrees of interactive semi-autonomous control. Theoretical efforts led to the formulation of models of supervisory control that clarify the dynamics by which operator and computer cooperate in trading and sharing control functions. Analysis of man-computer communication processes (for instance, how the operator enters control orders) has resulted in models of an interactive command language for manipulator control and in the specification of information feedback requirements so that the operator can be kept informed of the status of the system and progress of the task. Algorithms and computer software programs based on these models have been developed and successfully implemented in a teleoperator research facility. Their contribution to improved performance has been demonstrated in controlled laboratory experiments.

Other efforts have examined the effects of poor underwater visibility and delays in the transmission of control and display information (a result of using limited bandwidths). These investigations have led to the recommendation of ways to compensate for constrained communication channels, and have also provided data on the effects of different approaches to information display under poor visual conditions.

#### Utilization/Technology Base Advance

The theories of operator performance and models of supervisory control derived from these research efforts are being used in exploratory development programs conducted by the Ocean Engineering and Technology Division of the Naval Ocean Systems Center. These findings have provided guidelines for computer software and user interfaces which are being evaluated for use in an advanced, remotely controlled manipulator system and free-swimming submersible.

#### Payoff/Potential

Supervisory control concepts have been shown to improve operator performance with teleoperator systems under laboratory conditions by lightening the operator's load and allowing tasks to be completed more quickly and with greater precision. These laboratory-proven concepts can now be implemented in prototype hardware and evaluated under field conditions.

In addition to their application to underwater teleoperator systems, these concepts have a strong potential for application to other classes of Navy man-machine systems, such as remotely navigated surface and air vehicles.

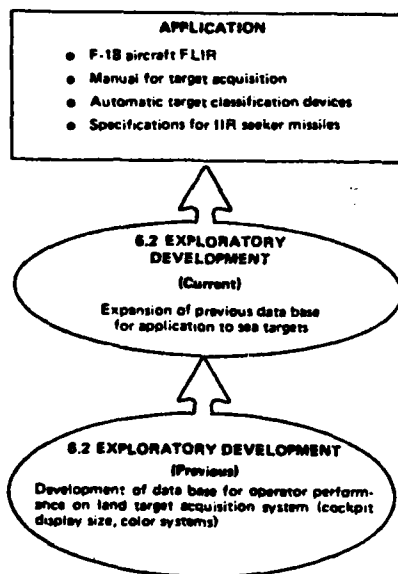
## OPERATOR PERFORMANCE WITH IMAGING SYSTEMS

### Need

One of the Navy's major functions is control of the seas; reconnaissance, tracking, and potential attack capabilities are required against neutral and enemy ships. A variety of electro-optical devices have been developed for use in the identification phase of these operations. These "imaging systems" are continually being improved, and new ones are being developed. Inputs on human operator performance with the proposed systems are needed so that design engineers and analysts can make design selections and estimate system effectiveness.

### Performing Activity and Program Element

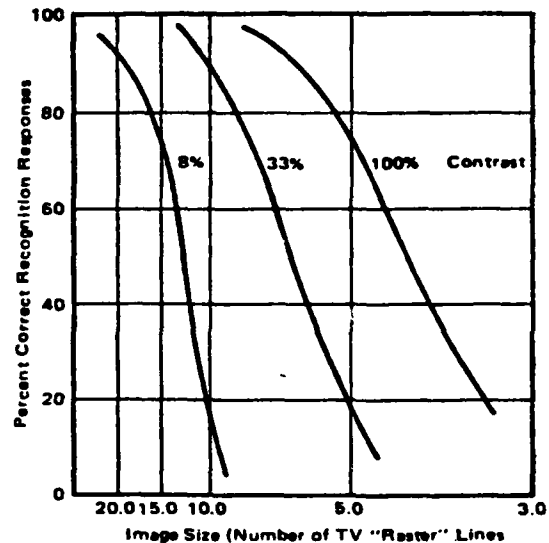
This effort was carried out by the Naval Weapons Center at the request of the Naval Air Development Center. The Program Element is 62757N. Program dynamics in support of this effort are depicted in the diagram below.



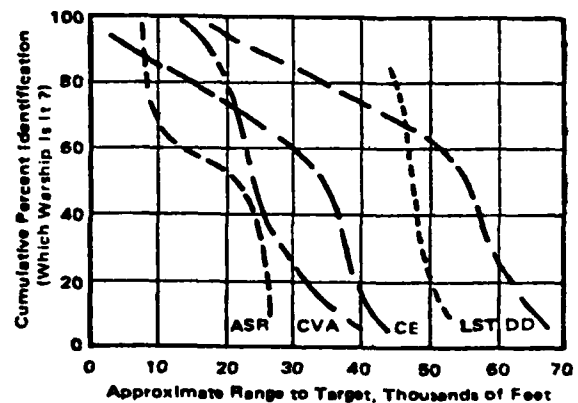
### Approach and Results

Laboratory experiments and analyses are being conducted to define the operational conditions and kinematics that are involved in system employment, and to quantify operator performance in such conditions. For example, the operation of an airborne forward-looking infrared system (FLIR) against ships and the use of a missile with an imaging sensor and data link back to the operator have been investigated and described. Elements of operator performance, including the geometry, sensor characteristics, operator tasks, and task time available, have been quantified. Laboratory

studies, flight tests, or both were used to collect data on operator performance at the tasks of ship identification and missile system operation. These studies were conducted using television, television simulating FLIR, and high-resolution radar. The two charts exemplify the kinds of data and results that are obtained in these experiments.



Probability of Combatant Ship Identification With Aspect Angle 45 Degrees off Ship's Bow



Cumulative Percent Identifications: Which Warship Is It? Data Are From Broadside View Only

The analysis that was subsequently performed used these data to quantify ship attack possibilities and to determine system characteristics such as sensor field-of-view and resolution.

#### Utilization/Technology Base Advance

The data base being built has already been used in estimating the effectiveness of the F-18 aircraft's FLIR, and in developing concepts of an anti-ship missile configuration. Some of the work will be useful in developing tri-service effectiveness manuals for target acquisition with imaging devices. In addition, the data base and accompanying analysis has led to procurement specifications for missile infrared seekers.

The study of operator performance in ship classification has led to the establishment of design goals for automatic target classification devices, and will also be used in evaluating the effectiveness of an improved radar for the A-6E aircraft.

#### Payoff/Potential

The findings of this project will allow procurement specifications to be more closely related to the required operator performance, and thus to mission

effectiveness. This is a clear example of the impact that human factors can have on design considerations. A memorandum from the head of an engineering team studying proposed imaging infrared (IIR) seekers to the director of the human factors department at the Naval Weapons Center states that the human factors work "proved to be essential in establishing requirements for an IIR seeker" and placed the Government in a "much improved position to validate or disclaim various contractors' approaches to IIR seeker weaponry."

The other result of this human factors research is that aircraft FLIRs, aircraft radars, and missile seekers will be more effective at target acquisition. This represents a very favorable investment. For example, the estimated cost of an anti-ship missile with an imaging seeker is more than \$600K. If one such missile is "saved" by including human factors inputs in the design, this part of the Human Factors Block Program at NWC has been paid for for a period of four years.

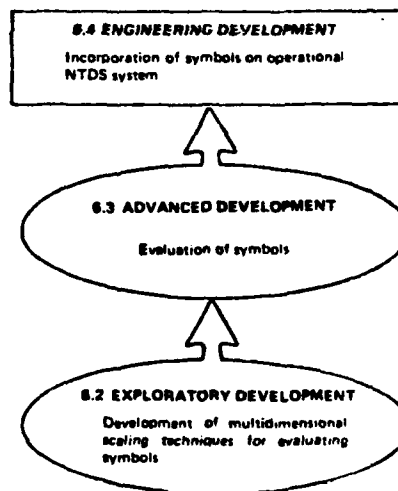
### EVALUATION OF POTENTIAL NTDS SYMBOLS

#### Need

The Navy Tactical Data System (NTDS) provides tactical information on visual displays via onboard consoles. The complex, high-speed, and heavy-load problems of modern tactical combat direction require the simultaneous display of a large amount of rapidly changing information. The quantity and variety of information is potentially overwhelming to the operator and to others viewing these displays. Thus, the design of displayed information must be carefully considered in order to reduce the possibility of confusion and ambiguity. If operators and commanders are to make immediate decisions and take appropriate actions, display symbols must be easily interpretable while remaining perceptually distinct from each other. Each time an updating or revision of the symbol set is contemplated, the issue of how to select display symbols that possess these properties arises. A better understanding of the factors contributing to the perceptual confusion of symbols would greatly facilitate the process of symbol set design.

#### Performing Activity and Program Element

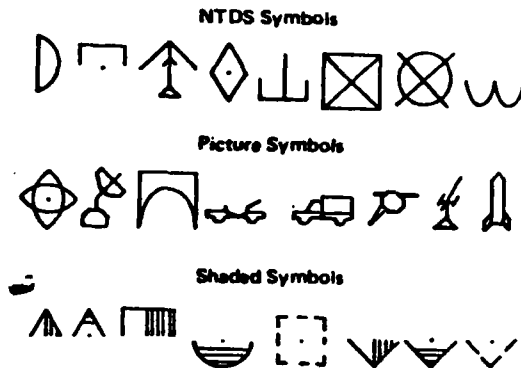
This project was performed by the Navy Personnel Research and Development Center under Program Element 63707N. Program dynamics in support of this effort are depicted in the diagram on the right.



#### Approach and Results

Research was conducted to assess alternative symbol sets for NTDS displays in order to identify the most salient characteristics or dimensions used by individuals in observing the symbols (see figure). Laboratory studies identified the important factors in the discrimination of NTDS tactical symbols. The data-gathering consisted of a multidimensional scaling

(MDS) task, with a number of participants. In particular, interest focused on the identity of the perceptual dimensions important for symbol discrimination, and on the efficacy of the MDS procedure for extracting these dimensions.



*Three Sets of Symbols That Are Being Evaluated for Use on the New NTDS Console*

It was found that under certain conditions conventional MDS procedures are inadequate for determining the important dimensions. When the criteria for distinguishing among a set of stimuli are ambiguous, observers' judgments of similarity between stimuli do not result in a successful multidimensional analysis. However, when a modification was made in the procedure so as to reduce this ambiguity, the analysis for the same sets of stimuli was more successful, and led to

an ordering of those characteristics of NTDS symbols that enable them to be distinguished from each other.

#### Utilization/Technology Base Advance

The staff of the Fleet Combat Directions Systems Support Activity (FCDSSA) have been concerned with the appropriate use of the extensive graphics flexibility that will be gained by the installation of the AN/UYQ-21 aboard ships as the standard NTDS display console. The findings of this and other related efforts are directed at resolving such operational problems and questions. On the basis of this information, hardware and software specifications for new systems can be derived that will promote a complementary match between the capabilities of the user and those of the system. FCDSSA is now aware of the pertinent considerations to be weighed when introducing new symbols to the existing set, and is armed with a method for assessing proposed symbols fairly easily and without the use of elaborate procedures. The modification in MDS procedures offered in this study is also a potential solution to a general problem involved in applying the MDS approach.

#### Payoff/Potential

Use of the information gained in this effort provides the military community with a methodology for studying the perceptual properties of symbols used to convey tactical information via graphic displays. System designers may now select and use symbols on the basis of criteria related to user performance. As a consequence, graphically displayed tactical information will be easier for the user to discern and utilize.

## ENERGY MANAGEMENT DISPLAY FOR THE AIR COMBAT MANEUVERING RANGE

#### Need

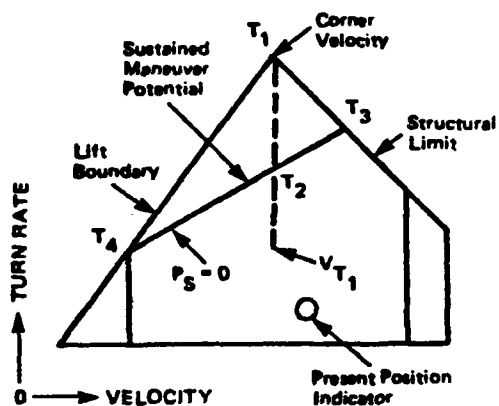
Development of the Air Combat Maneuvering Range (ACMR) has been a major step toward the standardization of Air Combat Maneuvering training. The capabilities of the ACMR system allow instructors and trainees to review flight data and analyze individual maneuvers and engagements far more objectively than was possible before the system was implemented. One aspect of air combat maneuvers and engagements involves the requirement for pilots to efficiently manage the aircraft's energy state. This requirement was recently highlighted during Navy Fighter Weapons

School (NFWS) symposia conducted at Naval Air Station, Miramar. Representatives of the fighter community documented a need to improve techniques for energy management training on the ACMR. This effort addresses that need by focusing on the development and implementation of an energy management display (EMD) to improve current energy management training on the ACMR.

#### Performing Activity and Program Element

The EMD was developed by the Pacific Missile Test Center as part of a project for improving air





Energy Management Display (maneuver triangle)

#### Utilization/Technology Base Advance

Use of the EMD as a training and debrief tool was evaluated during air combat training at the ACMR by the NFWS and other squadron personnel. It was found that the EMD enhances energy management (EM) training, especially during debriefs. Specifically, this training improved the recognition of energy gain/loss during maneuvers and the recognition of energy advantage/disadvantage of opponents.

The EMD program has demonstrated the feasibility of using flight data that are available from the ACMR to more efficiently display energy maneuverability information to the fighter pilots in training. The use of EMD for improving a pilot's qualitative analysis of energy state management is a step forward in energy management training on the ACMR. To support efficient utilization of the EMD, training materials such as videotapes and syllabi are presently being developed.

#### Payoff/Potential

This development resulted in a dynamic EMD which was endorsed by operational users as being required for improving EM training on the ACMR. The EMD has a potential to provide the following specific improvements in EM training:

- Reduction of training time for pilot mastery of specific air combat tactics.
- Enhanced understanding of EM concepts by fleet aircrews and increased pilot proficiency in air-to-air tactics.

## EDUCATION

DoD defines this area of People-Related RDT&E as "Development of educational/training methods or generation instructional systems for military application."

The Navy training establishment faces major challenges while it is faced with economic restrictions of weapons. New technology is being developed to reduce training costs and improve efficiency, and to train man and machine in their units.

Projects in this category include:

- Job Enrichment Techniques
- P-3 Aircrew Training
- JOBS: Instruction in
- Communication and
- Microcomputers in

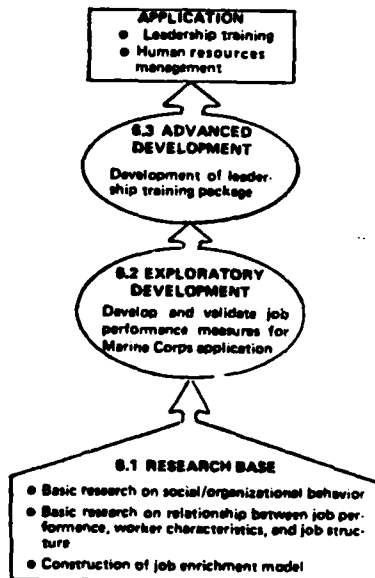
## JOB ENRICHMENT TECHNIQUES FOR MARINE CORPS LEADERS

### Need

Effective leadership training requires techniques that can be applied to the specific problems leaders face. A common problem is how to organize a work environment so that subordinates perform at maximum efficiency. Therefore, a series of basic research efforts generated a job enrichment model to help leaders create task environments that contribute to worker satisfaction and increased productivity.

### Performing Activity and Program Element

This project was funded and administered by the Office of Naval Research, under Program Element 61153N. Program dynamics in support of this effort are depicted in the diagram below.



### Approach and Results

A recognized university authority on organizational behavior developed measures of job characteristics and worker satisfaction that were validated against records of absenteeism, turnover, and productivity. Those aspects of the work setting that resulted in high levels of satisfaction and productivity provided the elements of a model of job enrichment. The important elements were: (a) meaningfulness of the work, (b) responsibility for the outcome of the work, and (c) knowledge of the actual results of the work activities.

Marine Corps officials built a leadership training package around this job enrichment model. The theory is presented in the training program, along with methods to (1) determine the extent of motivational problems, (2) diagnose their causes, and (3) implement procedures to remedy the problems.

### Utilization/Technology Base Advance

The job enrichment/job satisfaction materials are now used as the technology base for instructional material in the Leadership Instruction Division of the Marine Corps. These materials, including a case study of an application of job redesign applied to a Marine Corps Artillery Unit, present appropriate interventions. The application of this program is being monitored by the Chief of Naval Research's Special Assistant for Marine Corps Matters.

### Payoff/Potential

Job enrichment techniques provide leaders with validated approaches to measuring, evaluating, and improving on-the-job motivation. The observed outcomes of increased satisfaction include higher-quality work, lower turnover, lower costs, and higher productivity.

## P-3 AIRCREW TRAINING PROGRAM

### Need

In the past, P-3 aircrew training relied on traditional methods of instruction. These included group lectures, simulations of varying degrees of complexity, and one-on-one instructor-student flight training. This system yielded generally satisfactory results. However,

changing training requirements within the P-3 Fleet Replacement Squadron (FRS) necessitated a new aircrew training program.

The increasing complexity of aircrew jobs and the reduction of training resources require more efficient



training. A new syllabus was needed that would maximize training effectiveness and efficiency in the face of a sizeable reduction in aircraft flight hours and in personnel, and that would take advantage of new flight simulators and weapon systems trainers.

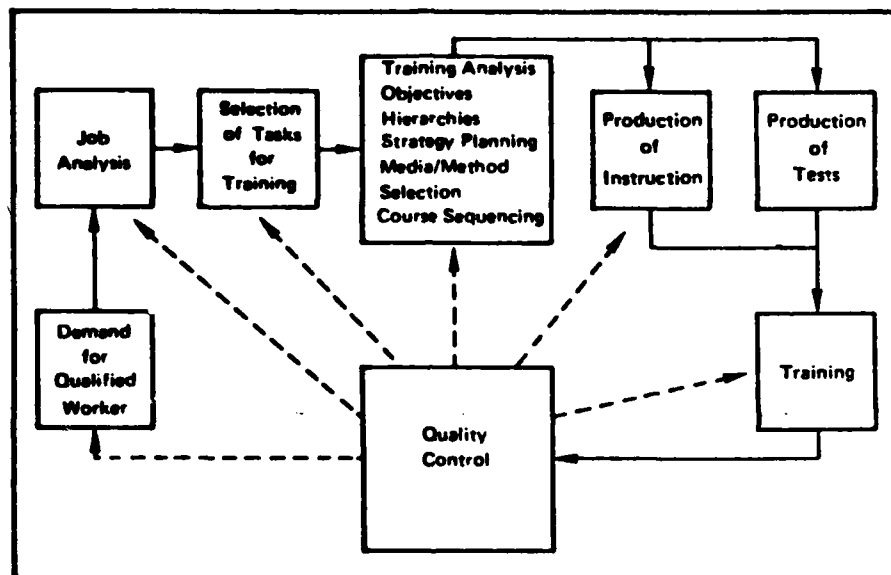
#### Performing Activity and Program Element

This program was initiated by Patrol Squadrons Thirty and Thirty-one, and supported by functional and type commands and the cognizant Chief of Naval Operations sponsor (OP-594). The Navy Personnel Research and Development Center was tasked to

perform this effort. Costs were reimbursed from Naval Air Systems Command funds.

#### Approach and Results

Instructional Systems Development (ISD) was applied in this program (see figure). This is a systematic approach to training that bases all training on the actual tasks performed by jobholders and on the instructional objectives that are derived from the tasks. It has been mandated for use in all DOD training development activities, and makes efficient use of the available resources to construct a complete and coordinated syllabus of instruction.



*Instructional Systems Development (ISD) Algorithm*

Under the guidance of NPRDC instructional psychologists, a team of Navy subject matter experts, instructional developers, and production specialists developed the necessary training. Fourteen separate courses of instruction were developed, ranging from five to twenty weeks in length. These courses included: 800 lesson workbooks of approximately 50 pages each, containing 4,500 instructional objectives; 150 tests tied directly to lesson objectives; 450 training device session guides, including device session procedures and grading criteria; 200 videotape programs; 125 slide-tape programs; guidelines for scheduled and impromptu seminar sessions, when required; and reference documentation, including a management plan, a quality control plan, instructor and subject-matter expert training materials, and a cross-referencing system for management of course components, referent documents, scheduled events, and resources available. The approximately 8,000 hours of instruction are delivered 10 times a year by each FRS.

#### Utilization/Technology Base Advance

Patrol Squadron Thirty-one, NAS Moffett Field, implemented the new aircrew training curriculum in October 1978. Since that time, all crewmembers have been trained in this program. A new complement of students is graduated every 25 days and sent to fleet deployed squadrons. Patrol Squadron Thirty, NAS Jacksonville, implemented the curriculum in January 1980 and will also train all crewmembers in the program.

This program is believed to be the largest aircrew ISD effort attempted to date, and is certainly one of the largest ISD programs ever undertaken by the Department of Defense. The ability of fleet units to respond to the requirements of such a large-scale ISD effort and still perform their mission was studied, as was the capability of functional and type commands to integrate the program into their ongoing training and support structures.

The degree and quality of management planning that took place in regard to the initial and continued use of this instruction constitutes a step forward in assuring coordinated and effective implementation. NPRDC is providing continued consultation and assistance to the two user squadrons, with respect to program management and other issues.

#### Payoff/Potential

The following payoffs have resulted from this program:

- P-3 FRS aircrew training is accomplished effectively, notwithstanding a 23% reduction in flight hours and the introduction of new flight simulators.
- Instruction has been individualized, so that each student receives the training that is best suited to his needs.
- Instruction is directed at achieving specific objectives of the training program, which are themselves tied directly to tasks performed by crewmembers.

- Standardization of training between the two P-3 user squadrons is achieved.
- Thorough documentation of all instructional components is available for reference and use by all interested parties.
- A system is in place and functioning to permit revisions and augmentation of instruction in a systematic and controlled manner.
- A management system is operating to integrate the instructional system with the other components of the FRS mission.

In addition, data gathering and planning are underway concerning the following potential payoffs:

- An increase in student throughput
- A reduction in total training costs per student
- Better trained crewmembers, who require less training and orientation time in fleet deployed squadrons to perform their jobs
- A reduced staff of instructors.

## JOBS: INSTRUCTION IN "A" SCHOOL-RELATED BASIC SKILLS

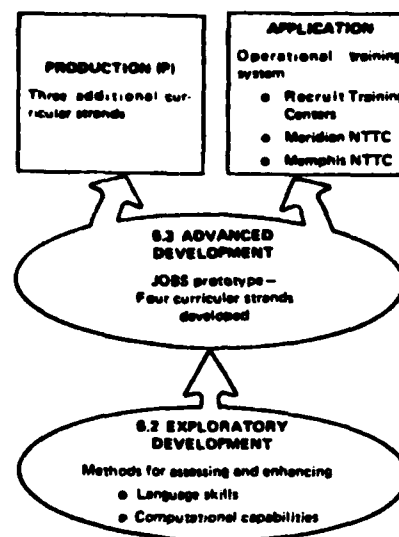
#### Need

Like the other services, the Navy faces the problem of a decline in the prime manpower pool: males in the 17-21 age group, in the upper three mental groups. Navy manpower planners are examining a number of ways to deal with this shrinking resource of new recruits. One option, the lowering of mental standards required for enlistment, would increase the number of enlistment eligibles. However, lower ability personnel typically have higher attrition rates than their brighter counterparts and are usually not qualified for training in more technical occupations. The Job-Oriented Basic Skills (JOBS) training program addresses these problems with a specialized training curriculum to compensate for educational skill deficiencies. It permits lowering the Navy enlistment quality standards while limiting attrition and allowing a broader use of such personnel.

#### Performing Activity and Program Element

This project was performed by the Navy Personnel Research and Development Center. Research and development funding was provided under Program Element 63720N. Additional funding support was received from the Chief of Naval Personnel and the

United States Office of Education of the Department of Health, Education and Welfare. Program dynamics in support of this effort are depicted in the diagram below.



### Approach and Results

The JOBS instructional materials incorporate the following design concepts: (1) training objectives are focused at building only those prerequisite skills and knowledges called for in the next stage of technical training; (2) practice exercises are taken directly from the subject material of the technical rating for which the student prepares; and (3) a strong emphasis is placed on the job-oriented nature of the training as the initial step in achieving a Navy technical rating. Four curricular strands were developed: Propulsion Engineering, Operations, Administrative/Clerical, and Electronics. In addition to the development of curricular materials, buildings were renovated at San Diego Naval Training Center and instructor services were obtained through the San Diego Community College District. The prototype JOBS training facility convened its first class on 30 July 1979. Students selected (1) volunteered for the program and (2) were below the maximum allowable Armed Service Vocational Aptitude Battery (ASVAB) cutoff for the follow-on technical rating. Preliminary results have shown that:

- The mean completion time for JOBS-qualified graduates in the Propulsion Engineering (PE) basic portion of their technical training was 18.7 days, while for their fully qualified "A" school counterparts it was 18.0 days.
- The attrition rate in PE basic for JOBS-qualified students was 14.8 percent, compared to 11.4 percent for "A" school qualified students.

These results indicate that JOBS graduates perform in technical training school at a level not greatly different from that of their fully qualified cohorts, even though 100 percent of JOBS students come from the lower mental categories (III lower and IV), whereas only 18 percent of the fully school-qualified entrants come from these mental category groups.

### Utilization/Technology Base Advance

The JOBS prototype training system operates at the Naval Training Center, San Diego, with an anticipated training input of 837 during the developmental stage. Beginning in January 1981, the training program will become a Navy-wide operational training system with sites at the Naval Training Centers in Great Lakes and Orlando, and at the Naval Technical Training Centers in Memphis and Meridian. A transition plan has been developed in conjunction with representatives from Chief of Naval Education Training (CNET), Chief of Naval Operations (OPNAV), Navy Military Personnel Command (NMPC), and NPRDC to insure a smooth transition from research to utilization. Expansion resource requirements have been identified, programmed, and approved in the POM 81 funding cycle. Evaluation will continue through FY 82.

### Payoff/Potential

The JOBS project directly addresses two operational problem areas. The first is to design, develop, and test a system of specialized training curricula to compensate for basic skills and knowledge deficiencies of lower-aptitude personnel entering the Navy. The second is to reduce the currently unacceptable rate of first-term attrition among General Detail Force Personnel (GENDETs). This will be accomplished by offering JOBS training as an incentive for providing trouble-free service as a GENDET. If the attrition suppression goal is met, an additional indirect benefit may be achieved, i.e., bringing a larger percentage of enlistees to a position where they can be recommended for re-enlistment. Finally, because changes in recruiting policy may produce an over-representation of racial/ethnic minorities in the GENDET force, this project has the potential for producing better minority representation across the Navy's occupational specialties.

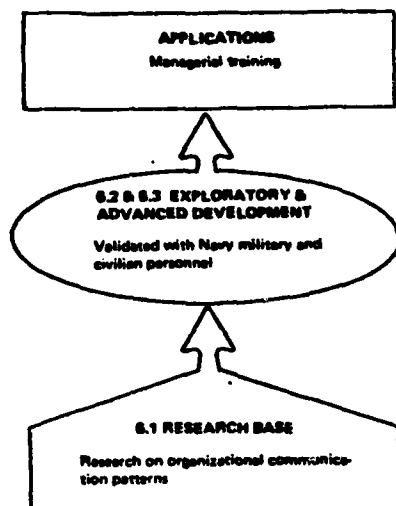
## COMMUNICATION AND MANAGERIAL EFFECTIVENESS

### Need

Many management problems can be attributed to poor communication. Before communication can be improved and resultant problems eliminated, a knowledge base of effective managerial communication is required.

### Performing Activity and Program Element

The project was funded and administered by the Office of Naval Research, under Program Element 61153N. Program dynamics in support of this effort are depicted in the diagram that follows.



#### Approach and Results

A theoretical two-stage communication model was developed for studying selected variables that pertain to communication style and effectiveness. Data were collected from both Navy managers and private sector managers. Some specific findings were that: (1) managers in organizations with traditional (as opposed to more sophisticated) technology tend to have more effective communication styles; (2) as the number of persons reporting to a particular manager increases, the effectiveness of that manager's communications tends to decline; (3) the appropriate use of formal, written

communication, as opposed to informal, face-to-face media, influences how clearly the subordinate sees the role of the manager; (4) familiarity through frequency of contact influences the effectiveness of managerial/subordinate communications; and (5) brevity, informality, and frankness are the major components of effective communication styles.

#### Utilization/Technology Base Advance

The initial findings were used as instructional material in a course entitled "Communication and Motivation," taught by the Naval Material Command Management/Administrative Training Center (NMC M/ATC). Later findings provided resource materials for the instructors and students at NMC M/ATC. This same investigation is providing a technology base for research and training on improved managerial effectiveness conducted by the Office of Personnel Management (OPM).

#### Payoff/Potential

Since this model has shown that communication affects managerial and work group effectiveness, improvements in communications will be beneficial. The knowledge gained in this work will heighten the relevance and quality of education and training intended to improve communication effectiveness. The results should also benefit efforts to increase organizational effectiveness, in which communication factors play a part.

## MICROCOMPUTERS IN SHIPBOARD SUBMARINE TACTICAL TRAINING

#### Need

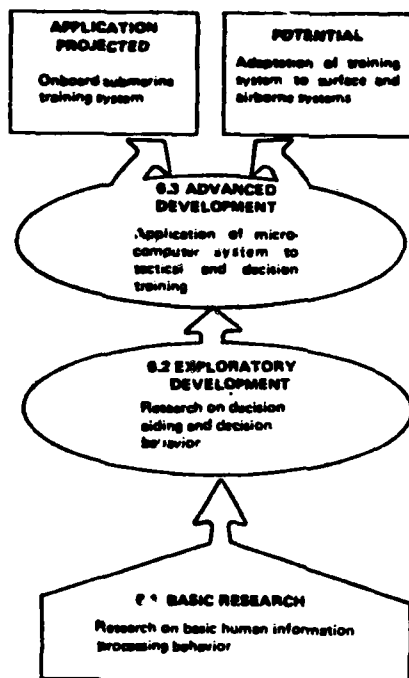
Tactical decisionmaking training for naval submarine officers has been confined to direct, at-sea experience and to team training on one of several submarine attack center trainers, such as the 21A40. Team training experience, although valuable in increasing individual skills, is costly and requires coordination and scheduling to accomplish. Moreover, most team training tactical scenarios require large computers and specialized software. There is a pressing need for individual training in tactical skills, but no practical method of implementing such training has emerged.

Increasingly widespread use of desktop microcomputers offers an inexpensive means of providing

individual training in tactical decisionmaking situations. One such computer, the Tektronix 4061, was recently acquired for installation aboard submarines. It has a great potential for use as an onboard individual training device by all submarine officers. Development of software to provide an interactive training capability is feasible and would be immediately useful.

#### Performing Activity and Program Element

This project was performed by the Navy Personnel Research and Development Center under Program Element 63707N. Program dynamics in support of this effort are depicted in the diagram below.



#### Approach and Results

Four types of operational skills were selected to demonstrate how microcomputers might be used to deliver effective tactical training:

1. Angle-on-the-bow recognition;
2. Telemeter ranging;
3. Mental geometry for target motion analysis; and
4. Decision training for submarine tactical analysis.

A package of programs was developed to provide experiential training in each of the selected tactical skills. The package was designed to operate on the Tektronix 4051, utilizing its graphics capability to evoke the features of onboard tactical information and sensor display systems, such as the periscope and sonar repeaters. To receive training, an individual takes advantage of some convenient opportunity to run a

selected program. These programs are stored on small tape cartridges and can be easily loaded onto a Tektronix 4051 with a memory capacity of 32K ROM. Each program features complete user instruction, unlimited practice and test problems, performance feedback, and a score retrieval capability. Levels of difficulty are assigned to the test problems based on the trainee's performance at each program level. Each program provides diagnostic evaluation and weighted scoring. Data may be stored and/or retrieved from specific individual files, thus allowing for either immediate feedback or later performance evaluation of the trainee. This evaluation can be used to guide a trainee from basic through advanced levels of difficulty in each program.

#### Utilization/Technology Base Advance

Submarines and submarine training facilities now employ the Tektronix 4051 for tactical support. Its use as an individual training device has not been adequately demonstrated. Yet its prevalence provides an opportunity for individual tactical training at low cost and without interfering with submarine schedules. Junior officers can take advantage of these programs to sharpen tactical skills without employing more expensive, large-scale combat control equipment. The use of such programs on a small scale must be viewed as an advance in training technology with an immediate operational application.

#### Payoff/Potential

Any gain in submarine officer tactical skill is of great value to the fleet, particularly when the developmental cost is so low. Once the programs have been given final evaluation and are accepted by the type commanders, each submarine in the force can have the complete set. Besides the increase in officer skill levels that the programs can produce, they will also provide commanding officers with a simple record of individual progress in those areas covered by the material. Continued use of the programs allows users to become acquainted with computer programming, so that more useful tactical training and support systems might be developed later.

## **SIMULATION AND TRAINING DEVICES**

DoD defines this area of People-Related RDT&E as follows:

"Development of cost effective training equipment and technology that produce the needed performance for operation and maintenance of military systems."

The Navy needs training devices and simulators for several purposes: to improve readiness through realistic exercise; to reduce training costs; to increase safety during practice of dangerous activities; and to reduce the destructive impact of training activities on the environment. Following Congressional guidance, several program elements have been established to accomplish these objectives.

Projects in this category include:

- **Surface Navigation and Orientation Trainer**
- **Laser Air-To-Air Gunnery Simulator**
- **Automated Air Traffic Controller Training System**

## SURFACE NAVIGATION AND ORIENTATION TRAINER

### Need

Land navigation training has always been one of the most difficult courses facing the new Marine. Development of skill in this area is crucial for the successful execution of military missions. Yet training for these skills has become less certain. Map reading and land navigation are no longer being taught to U.S. Marine Corps recruits during their basic training. The Corps anticipates that the skills will be acquired in a variety of ways, for example through extension courses prepared by the Marine Corps Institute (MCI), through instruction given by other battalion members in the form of on-the-job training (OJT), or through formal schools.

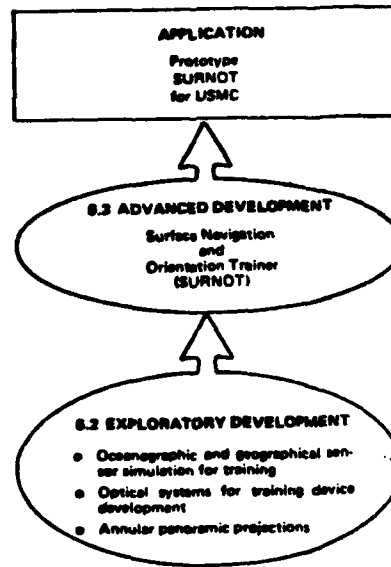
The Marine enlisted infantry member's first exposure to land navigation training is usually at Infantry Training School (ITS). At present, the curriculum devotes only eight hours to map interpretation and land navigation. Because of this short training time, no student leaves ITS with a working knowledge of either compass or map.

The MCI has developed programmed instructional packages for teaching students the mechanics of map and compass. Although the MCI courses are of the highest quality, they do not include field work in which students can gain practical experience. Also, there is no formal requirement for NCOs to complete the extension course for promotions.

On-the-job training for the infantryman currently depends upon the training objectives established by Division Headquarters, and is not standardized. The quality of instruction varies depending upon the knowledge of personnel responsible for administering the training. Most of the basic principles are conveyed through lectures, with hand-drawn illustrations prepared by company personnel. Little, if any, field experience is received or available as part of these classroom instructions.

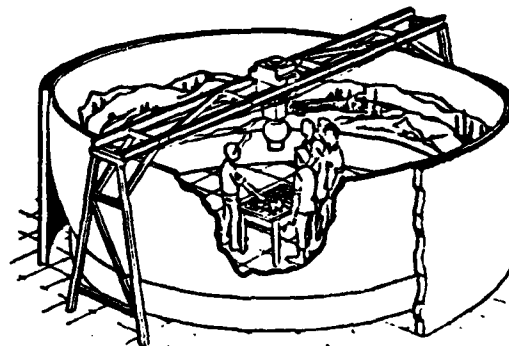
### Performing Activity and Program Elements

The Surface Navigation and Orientation Trainer (SURNOT) originated as a Navy-funded exploratory development project at the Naval Training Equipment Center (NTEC). Funding was originally provided by Program Element 62757N and is currently funded by the Marine Corps under Program Element 63732M. Program dynamics in support of this effort are depicted in the diagram above.



### Approach and Results

The SURNOT simulates real world situations in which the student can learn and practice land navigation. SURNOT is a 360°-wide, slide-projected picture in good resolution and in full color. A graphic representation of the SURNOT is presented here. Inside the trainer, the student sees actual photographs taken at selected locations. At each "location," the student sees the terrain that is depicted on his map or training materials.



Artist's Conception of the Surface Navigation and Orientation Trainer (SURNOT)

The SURNOT is designed to provide an environment in which the Marine can undergo the field training exercises that are considered essential for practical land navigation. Unlike traditional map reading exercises which are confined to a given area, the SURNOT offers a great variety of topographic and land-use conditions. A full range of geographic characteristics are available: jungle, desert, farmland, mountains, tundra, and urban areas. Seasonal or battle-damaged changes to a locale may be presented.

The 360° x 45° pictures are taken with a specially designed reflective-refractive lens attached to a commercial 4" x 5" camera using either color or black-and-white film. The film transparencies can be developed at any base photo lab, using standard photographic processes. The same photographic lens is then combined with a lamp house and a slide changer to become the projector for the annular images. A spherical screen about 11 feet high surrounds the projector and is viewed from the area beneath the projector. The picture is continuous and angles are true, matching the actual geography. The slide changer magazine is capable of holding 16 slides, which is ample for a normal class period.

The prototype SURNOT was evaluated at Camp Lejeune, North Carolina, in November 1979 and at Fort Rucker, Alabama, a month later. The results demonstrated that the trainer has good potential for accomplishing its orientation and land navigation objectives. The majority of the Marines who participated in these evaluations expressed a desire to see the SURNOT used in a variety of training situations, such

as shipboard training, briefing for combat missions, training for urban combat, training using foreign maps, reconnaissance training, tactical planning, and tactical decisionmaking.

#### Utilization/Technology Base Advance

The Surface Navigation and Orientation Trainer will be used at selected Marine and Army Training Centers where there is a large student throughput, or where intensive training is needed for special-assignment teams. This project has advanced the technology base for the use of 360° or other extreme wide-angle visual displays.

A related effort at NTEC has been a 360° non-programmed visual system using a scanned laser technique.

#### Payoff/Potential

The principal payoff from this trainer is an ability to provide more effective squad-level training in confined spaces. An improved quality of training can be expected, along with benefits in logistics safety and costs. Using the trainer:

- (a) Training can be conducted at any time, without regard to scheduling or weather.
- (b) There is no cost requirement for transporting trainees to a variety of geographic locations.
- (c) Instant location changes are possible for continued training without time losses.
- (d) Orientation pictures are possible before combatants reach the battle or target zones.

## LASER AIR-TO-AIR GUNNERY SIMULATOR

### Need

Air-to-air gunnery training is becoming increasingly difficult for the Naval Air Training Command to accomplish, due to growing restrictions on the airspace requirements for live ordnance firing. In addition, it requires considerable resources to conduct live gunnery.

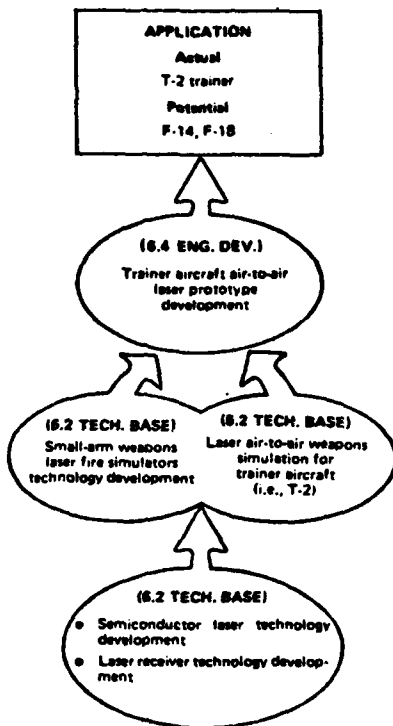
The Navy needed a safe method of conducting air-to-air gunnery over inhabited land areas. Such a system should allow the pilot to fly actual missions, with little or no loss of realism. Ideally, it should also sup-

ply automatic feedback to the pilot, and should cost no more than gunnery training with live ammunition.

### Performing Activity and Program Elements

This research/developmental effort was performed under the direction of the Naval Training Equipment Center. Early technology that led to this effort was funded under Program Element 62757N. The present effort is funded from Program Element 64703N. Program dynamics in support of this effort are depicted in the following diagram.





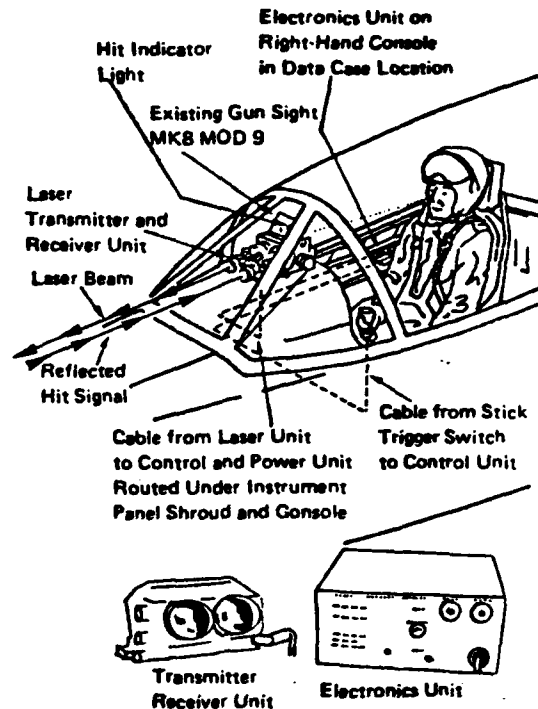
#### Approach and Results

NTEC developed a gunnery practice system based on the use of inexpensive, eye-safe laser transmitters and receivers to simulate firing live rounds.

Laser simulation has the great advantage of providing an unlimited source of hazard-free "ammunition" at a negligible cost per round. The approach used here relies upon electro-optic technology that has been undergoing exploratory research and development at NTEC since 1967. Previous exploratory applications of this technology are the Laser Marksmanship Rifle Trainer and the Helicopter Door Gunnery Trainer.

The fixed pipper air-to-air (T-2, Buckeye aircraft) laser gunnery system consists of a pulsed, gallium arsenide semiconductor laser transmitter system which is boresighted with the aircraft's fixed sight. The illustration shows the system installation in the T-2 aircraft. In the Naval Air Training Command, students fly a fixed geometry. The laser transmitter can therefore be boresighted to a fixed spatial geometry, offset to account for the lead that is necessary with real ammunition. If the pilot is properly tracking the target, the transmitted laser pulses will be reflected back from a regular towed banner, which is coated with retro-reflective paint. The reflected laser pulses are detected at the firing aircraft by a laser receiver containing an "avalanche photodiode." Avalanche detectors are the semiconductor equivalents of photomultiplier tubes, but are more rugged. They enable the detector to have gain, and hence a high signal-to-noise ratio. Electronic counters in the laser receiver count both the rounds

fired and the hits scored. The receiver is range-gated to prevent the pilot from firing beyond the effective range of the guns. A light attached to the aircraft sight flashes whenever a hit is scored. This feature gives the pilot instant visual feedback on his performance.



Artist's Conception of Laser Air-to-Air Gunnery Simulator Installation

The prototype system has been built. Test and evaluation efforts were conducted by the Naval Air Test Center at Naval Air Station Patuxent River, Maryland, during 1979. Results indicate that the system is well adapted to the T-2 aircraft and that it shows great potential for undergraduate pilot training. Operational evaluation will be conducted at Naval Air Station Key West, Florida, in 1980. Five engineering models of the system will be tested there.

#### Utilization/Technology Base Advance

The first products of exploratory research in weapon fire simulation are currently in use. The Tank Gunnery Trainer, first developed by the Naval Training Equipment Center, is now a Federal stock item being used by both the Army and Marine Corps. The Marine Corps plans to use the Laser Marksmanship Rifle Trainer to identify trainees who will experience problems firing the M-16 rifle. Service utilization of the laser gunnery training system by the Chief of Naval Air Training is planned for FY 81.

### Payoff/Potential

There are a number of substantial savings and advantages associated with using the laser system. First, no ordnance crew is required on the ground. Second, there is no ammunition to pose hazards to personnel or equipment, and no environmental damage. The only limitation to the number of rounds fired is the amount of flying time available. These two factors alone, the elimination of the ordnance crew and the reduction of live ammunition expenditures for training, will save millions of dollars annually.

A third advantage is that feedback to the trainee on hits scored is instantaneous and objective, since the laser beam itself hits a console-mounted device. A fourth important benefit is the fact that, because the laser beams are eye-safe, no cleared ranges are required. With airspace cleared for gunnery training becoming increasingly cramped or remote, this is a major advantage for training.

Now underway is an evaluation of a moveable pipper system that could be employed by operational aircraft such as the F-14 and F-18.

## AUTOMATED AIR TRAFFIC CONTROLLER TRAINING SYSTEM

### Need

The current method of training controllers is by means of Ground Controlled Approach/Air Intercept Controller (GCA/AIC) trainers. These devices require an unnecessarily high ratio of support and instructional personnel per trainee. Existing simulators were also not intended to offer the variety of controlled practice that is possible with newer technology. Current practices for assessing trainee performance are often subjective, and can place too great a burden on human memory. Students and instructors alike often find it difficult to recall the entire sequence of events.

Training is provided to the student on basic procedural concepts, but a heavy reliance on "live" follow-on training is essential to establish proficiency. Actual operational conditions certainly present situations that challenge even the most prepared student, but a "live" problem situation does not allow the luxury of stopping to learn. Accordingly, this follow-on training is expensive and, often, neither the instructor's nor the student's time is used efficiently. (This does not alter the fact that "live" training time is invaluable for complete comprehension of the controller environment.)

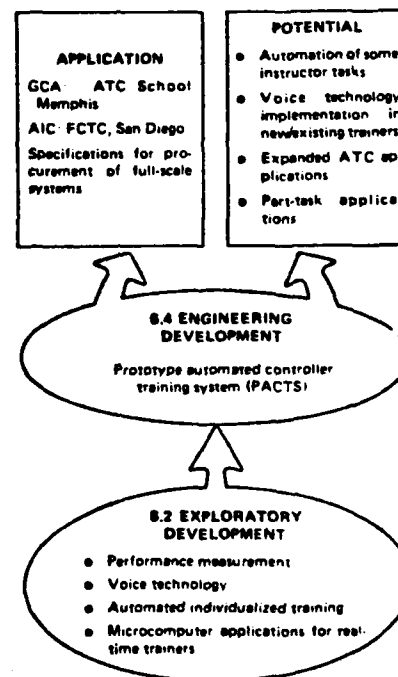
The effective use of current GCA/AIC trainers is also limited by the necessity for Navy instructors to perform activities that diminish direct training interaction with student controllers. During a simulator session, for most devices, up to 20 percent of an instructor's time must be devoted to such routine activities as problem set-up, student briefing, scoring, and historical record-keeping of student performance. As a result, there is a wide variation in the quantity and quality of simulator training. In turn, upon completion of training students do not have uniform skill levels.

The goal of reducing manpower costs while improving readiness of graduates or reducing training

time can best be met by developing self-operating, fully automated, individualized instructional technology for controller instruction. The need for such a system was documented by the cognizant training schools, and initiated by a CNO-approved NDCP dated July, 1977.

### Performing Activity and Program Elements

This project is being performed at the Naval Training Equipment Center, Orlando, Florida. Funding is being provided under Program Elements 62757N and 64703N. Program dynamics in support of this effort are depicted in the diagram below.



### Approach and Results

The project was based on research results from several exploratory development efforts in performance measurement, automated individualized training, microcomputer/microprocessor applications, and voice technology. This latter effort produced a laboratory capability for realtime Limited Continuous Speech Recognition (LCSR) of numbers by a computer.

The hardware/software packages implemented for Ground Controlled Approach (GCA) training will be "add-on" improvements to, rather than replacements for, existing simulators. Moreover, the automated training packages will be limited to certain select portions of the curricula. One prototype will concentrate on the early stages of instruction in Precision Approach Radar (PAR) control. A second, "stand alone" prototype will support the learning of basic procedures by Air Intercept Controller (AIC) students. Although self-contained stand-alone versions will be used for initial checkout for GCA training, the final products are intended for interfacing as "add-ons" to existing systems. Lessons learned, along with further development of the technology, will ultimately permit fully automated individualized instruction (through voice technology) in any future controller training simulators.

Throughout this development, participation by fleet instructors from the GCA and AIC schools has enabled the implementation of the prototype systems to proceed with maximum effective training results. Expected results from prototype implementation include:

- Diminish the burden of secondary functions on the instructor.

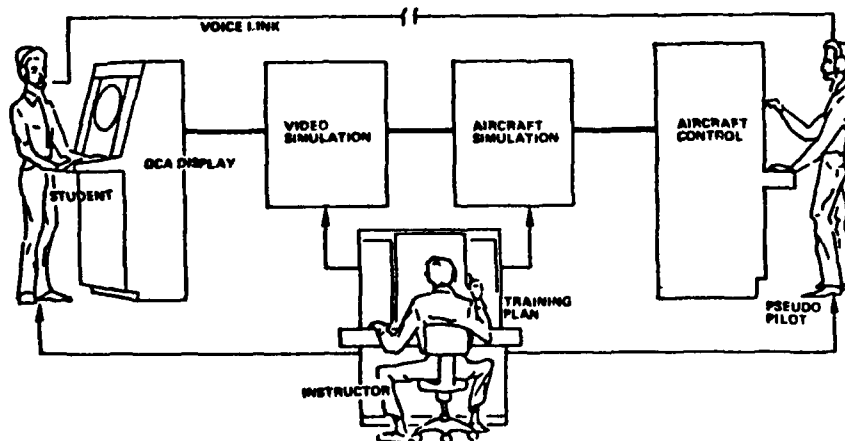
- Improve student/instructor ratios.
- Introduce objective evaluation of trainee performance.
- Increase the degree of training standardization.
- Eliminate the high cost associated with "pseudo-pilots" needed in some stages of current training.

### Utilization/Technology Base Advance

The GCA prototype system has been developed and is installed at the Air Traffic Control (ATC) School in Memphis, Tennessee. Evaluations of the system and determination of the degree of training effectiveness will take place throughout FY 80. Upon completion of this evaluation phase, necessary modifications will be accomplished, and production units will be procured for full-scale implementation in the GCA training portion of the ATC course.

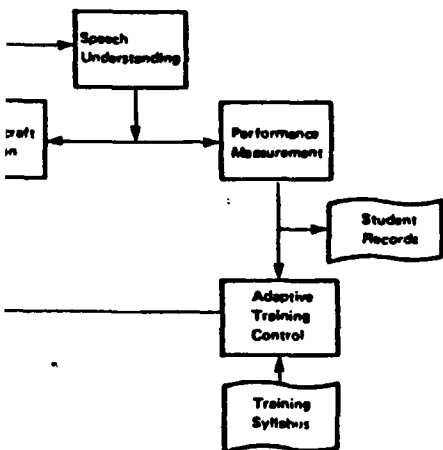
The AIC prototype development will continue throughout FY 80, and the prototype will be installed as a component of the AIC training course at the Fleet Combat Training Center, Pacific, in San Diego. Fleet evaluation, training effectiveness studies, and necessary modifications should be accomplished during FY 81, upon procurement of production units for full-scale implementation.

The operating concept of these automated systems developed for controller training is depicted in the two accompanying illustrations. The first figure depicts the GCA training system currently in use, and the second one shows the system as it will function with the automated package. The AIC training system will operate in a similar manner.



GCA Training Concept - OLD





ing Concept-NEW

### AIC Course

The AIC course now requires six weeks for completion. The annual student throughput is 200, with a 25 percent attrition rate. Each class consists of 5 students, with one instructor required for each trainee. School staff personnel function as pseudopilots. The last three weeks of the course consist of live runs in actual fleet aircraft. Successful implementation of the AIC automated package could provide the following benefits:

- An annual saving of over 24,000 hours of required training time.
- Elimination of pseudopilot requirement, saving over 20,000 hours of required support personnel time.
- The use of actual aircraft for the last three weeks of the course could be eliminated, saving 24,000 required flight hours, along with associated squadron support manhours, annually.
- Instructor/student ratio changes from 1:1 to 1:5.
- Reduction of required instructors by 80%.
- Training will be standardized.
- Attrition rate and required OJT time could be reduced by 50%.

The results from this development will also produce specifications for use in future procurements requiring automated capability similar to that of these two prototypes.

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This is the third annual report of the utilization of people-related technology base advancement in four technical areas: Manpower and Personnel, Human Factors Engineering, Training Devices. Each example is discussed in terms of Element, Approach and Results, Utilization/Technology

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